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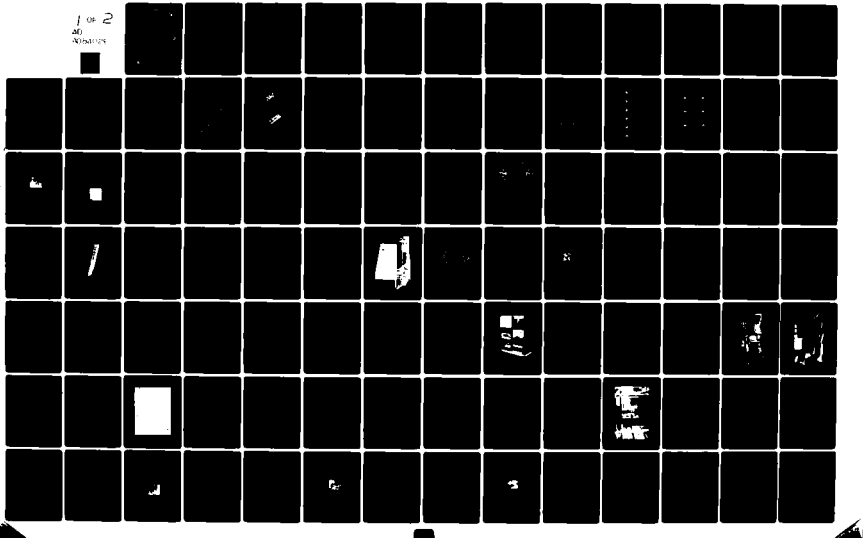

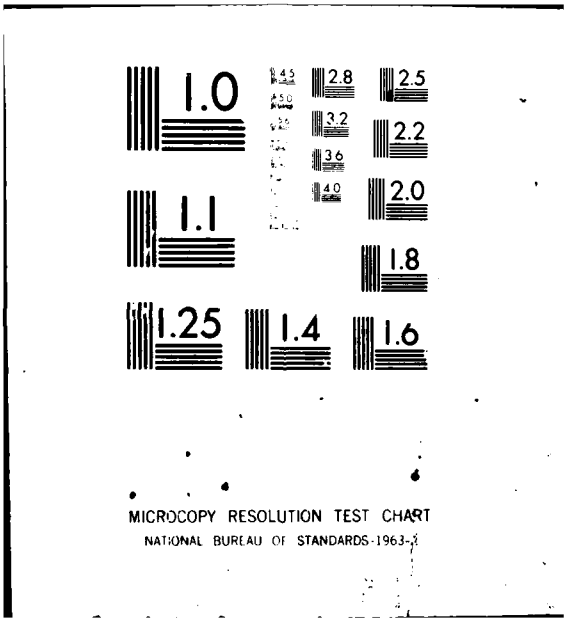
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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Maryland 20084

COMPUTATION, MATHEMATICS AND LOGISTICS DEPARTMENT REPORT FOR FISCAL YEAR 1978

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COMPUTATION, MATHEMATICS AND LOGISTICS DEPARTMENT
RESEARCH AND DEVELOPMENT REPORT

March 1980

DTNSRDC-80/034

COMPUTATION, MATHEMATICS AND LOGISTICS DEPARTMENT REPORT FOR FISCAL YEAR 1978 DTNSRDC-80/034

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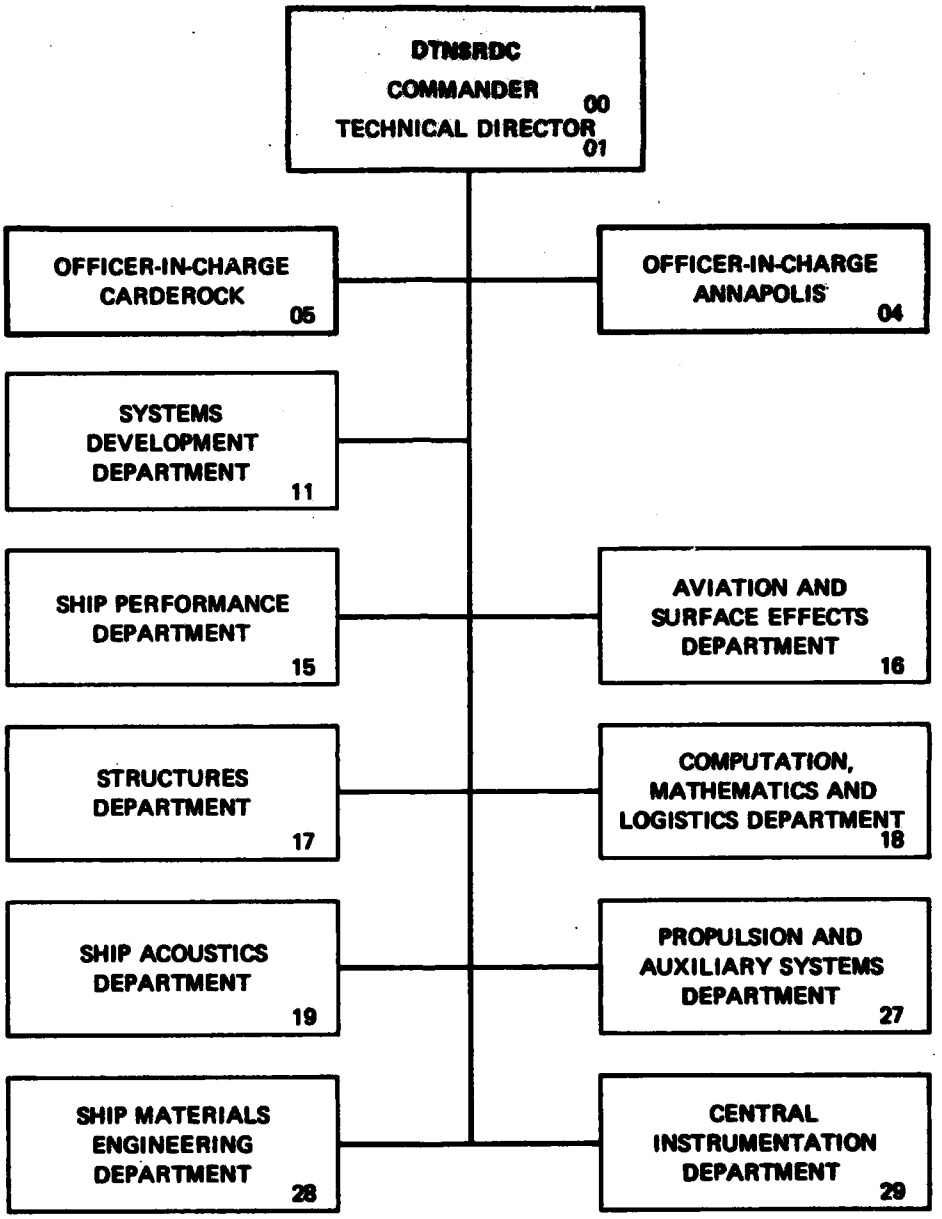

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This report summarizes the progress made during FY78 by the staff of the Computation, Mathematics and Logistics Department in programs generally designed to develop and exploit mathematical and computational technology for the Navy. Significant accomplishments were realized in numerical fluid mechanics, computer aided ship design, logistics analysis, and logistic information systems. Our participation in Navy-wide efforts concerned with

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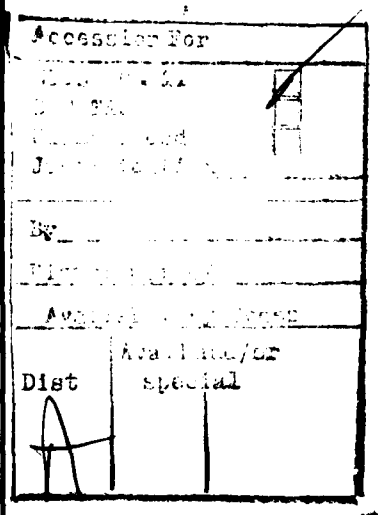
sharing of both computers and data continued and expanded. These and other Department projects are discussed in this report.



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FROM THE DEPARTMENT HEAD

This report describes the technical programs conducted by the Computation, Mathematics and Logistics Department of the David W. Taylor Naval Ship Research and Development Center during FY78. Significant technical progress was made in the major areas for which the department has responsibility.

We are proud of the accomplishments described in this document and of their contribution to the betterment of the Navy. This record is possible only because of the competence, dedication and loyalty of the members of our staff and the continued support and cooperation of our sponsors. We expect to continue to make creative and constructive contributions in the years ahead.

G. H. GLEISSNER

ABSTRACT

This report summarizes the progress made during FY78 by the staff of the Computation, Mathematics and Logistics Department in programs generally designed to develop and exploit mathematical and computational technology for the Navy. Significant accomplishments were realized in numerical fluid mechanics, computer aided ship design, logistics analysis, and logistic information systems. Our participation in Navy-wide efforts concerned with sharing of both computers and data continued and expanded. These and other Department projects are discussed in this report.

NUMERICAL MECHANICS

For over ten years the Department has been actively contributing to the field of numerical mechanics and its application to problems of naval importance. This dynamic and relatively new field has evolved as a result of the advances in, and interactions among, three disciplines: mechanics, numerical analysis, and computer science. Originally, the research concentrated on the three distinct subfields, of numerical fluid dynamics, structural mechanics, and acoustics. However, the progress made in each of these areas and the need for solutions to more difficult and comprehensive fluid-structure interaction problems soon stimulated an increase in the number and scope of numerical mechanics projects.

In addition to contributing to the success of the on-going numerical hydrodynamics project in the solution of ship-wave problems (an effort pursued jointly with the Ship Performance Department), the work in numerical mechanics included other interdisciplinary projects, such as the analysis of the dynamic elastic response of a submarine to underwater nuclear explosions. Recently, the interdisciplinary nature of the work has been further extended to include problems in the field of hydrodynamic noise (transient noise due to fluid flow and structural vibrations), magnetohydrodynamics, electromagnetism, and heat transfer. The underlying basis for this range of applications is the fact that these seemingly diverse fields are governed by a single class of mathematical equations. Hence, the methods of solution developed in one application area can often be adapted to another field by appropriate physical interpretation of the variables and parameters involved, by modification of the initial and boundary conditions, and by the introduction of auxiliary equations (constraints). Moreover, the numerical methods and computer programs, including graphics software, developed for solving these basic partial differential equations and analyzing the solutions in one application area, can also often be adapted to obtain solutions to problems arising in other areas.

This interdisciplinary approach with emphasis on both the physical soundness of the mathematical formulations and the quality of the numerical solutions provides cross-fertilization among the contributing disciplines

which benefits the entire field of numerical mechanics. The detailed progress cited in the following sections attests to the high degree of flexibility already achieved and indicates the opportunities for even more significant accomplishments.

NUMERICAL FLUID DYNAMICS

Over the past several years CMLD has built up a strong capability in the area of numerical fluid mechanics. The aim has been twofold: (1) to develop basic mathematical and computer methods for solving classes of fluid flow problems, and (2) to apply these methods to advance the state-of-the-art of computer simulation of fluid motions pertinent to hydromechanics research and naval engineering. The strength of this capability is the result of a well-coordinated effort which blends together elements of mathematics, computer science, numerical analysis, fluid mechanics, and naval/marine engineering.

During FY78, emphasis continued to be placed on developing numerical approaches which optimize use of the Texas Instruments Advanced Scientific Computer (TI ASC) at NRL and of boundary-fitted coordinate systems for the purpose of modeling a more practical and flexible class of fluid flow problems. Thus, three-dimensional, non-linear, free surface (interface between air and water), and high Reynolds number phenomena continue to be major areas of investigation. In addition, increased emphasis was placed on developing interactive graphics systems which aid the naval research and engineering communities to more efficiently perform a variety of data-related tasks. The following discussions highlight major milestones of the past fiscal year and demonstrate the cumulative strength and versatility of the Department's expanding capability in numerical fluid mechanics.

Geometric Definition of Arbitrarily-Shaped Flow Domains

Work has continued on making improvements in NUMESH, a program developed to numerically generate two- and three-dimensional boundary-fitted curvilinear coordinate systems. Refinements have been made which allow the program to take advantage of the vector processing and array handling capabilities of the Texas Instruments Advanced Scientific Computer (TI ASC).

Several views of grid systems about ship-like bodies in three-dimensional regions are shown in Figures 1 and 2. Also shown in these figures are the simpler computational regions associated with each physical region.

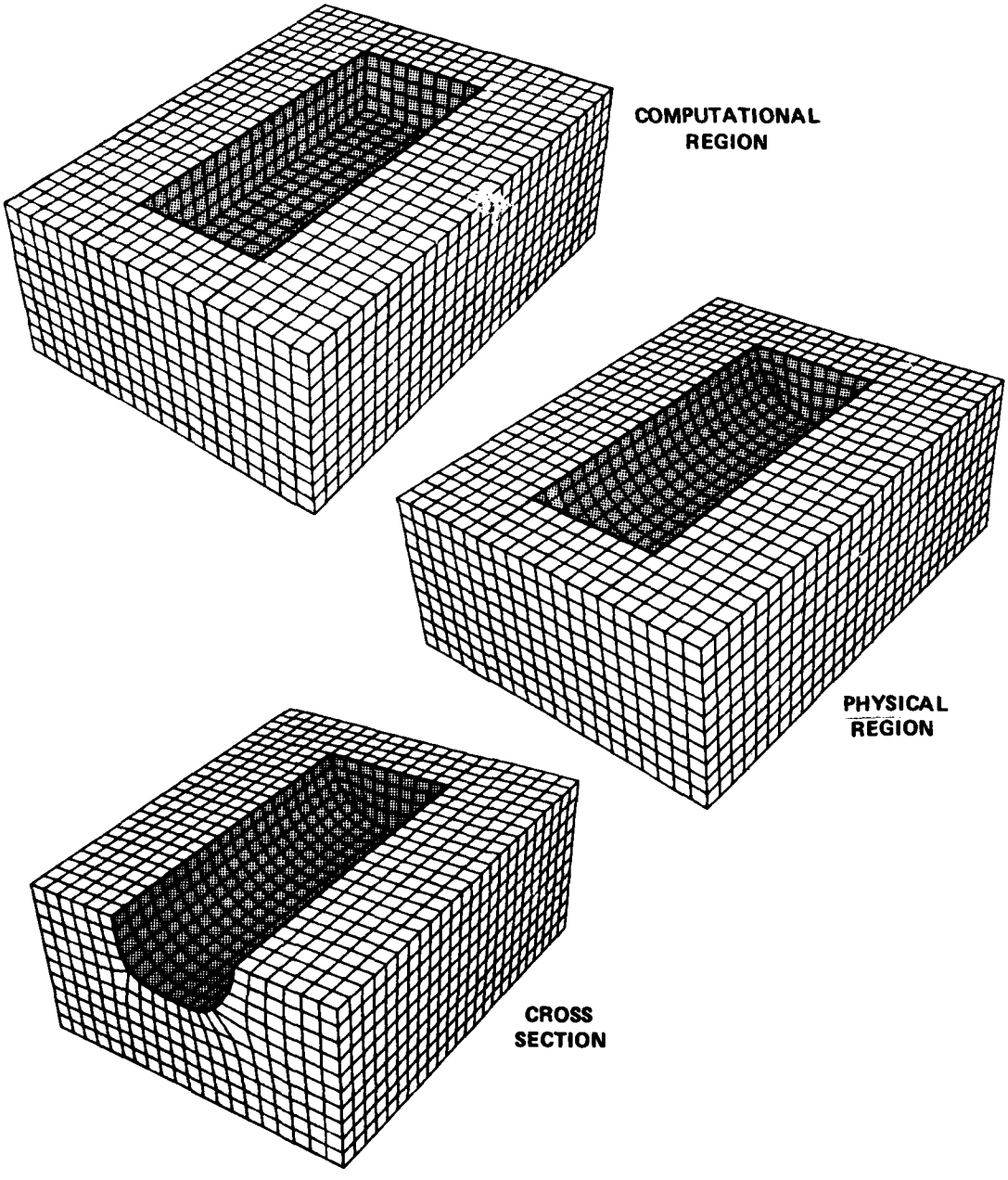


Figure 1 - Finite Circular Cylinder Transformation

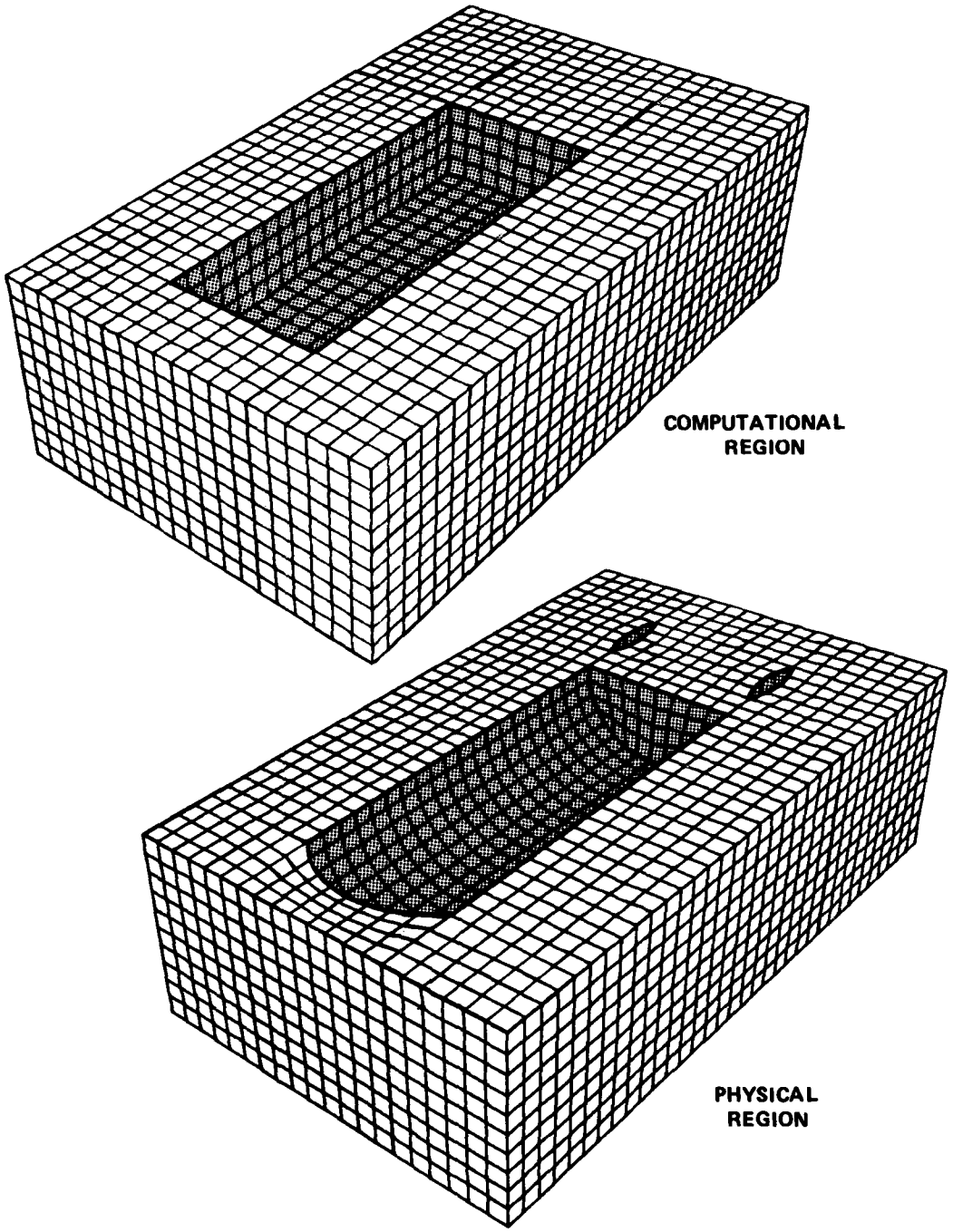


Figure 2 - Multibody Transformation

The latest version of NUMESH also allows the user to exert more control over the meshes that are generated. This control feature can be used to obtain higher resolution in local regions where high accuracy is needed. It is best illustrated by considering different grid systems generated for the same physical region. In Figure 3, the upper mesh was created using this coordinate control technique, whereas the lower one was not.

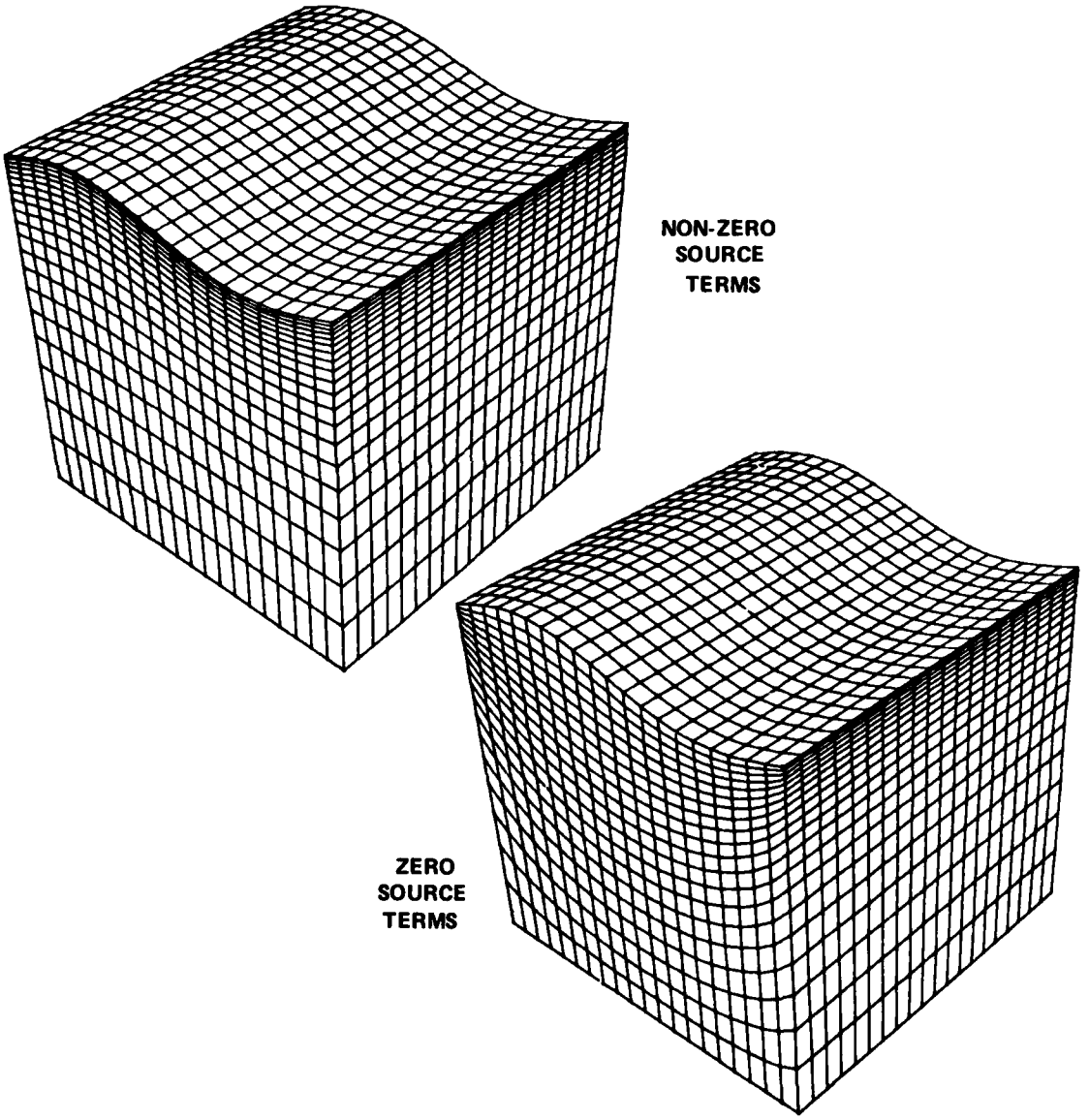


Figure 3 - Coordinate System Control

Fluid flow problems presently being solved using boundary-fitted coordinates include the following:

(1) in two dimensions: large amplitude waves nearing the point of breaking

(2) in three dimensions: a ship moving in a channel at an angle of attack.

Free Surface Flows

Nonlinear Ship Waves. Numerical solutions of large-amplitude nonlinear ship wave problems are yielding important information concerning the conditions under which commonly used linearized theories are inaccurate. Finite-difference techniques with boundary-fitted coordinates have been used to study the flow generated by a circular cylinder accelerated horizontally below a free water surface. When the cylinder is far below the surface (deep submergence), the linear and nonlinear results are, for practical purposes, identical. At moderate submergence the nonlinear flow evolves to a steady-state which exhibits steeper wave slopes than the linear state. For shallow submergence the nonlinear waves grow until breaking conditions are reached, indicating that a steady-state potential flow does not exist and that the linearized results are unrealistic. Figure 4 displays streamlines as the free surface approaches breaking conditions.

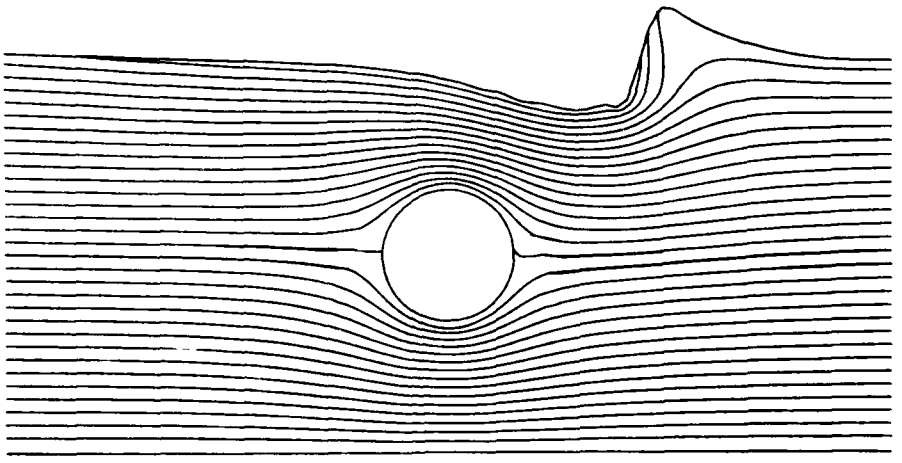


Figure 4 - Streamlines for a Breaking Wave Generated by an Accelerated Circular Cylinder

Other current studies of nonlinear waves deal with large-amplitude ship motions, stern waves, and the details of the breaking process. The method of lines is being examined as an alternative to the presently-used finite-difference method.

Steady Flow Past a Ship in a Free Surface. The XYZ Free Surface Program, which computes steady flow past a ship in a free surface, was further developed by the addition of routines to compute sinkage and trim. The ship can now be made to move and can be trimmed so that the added buoyancy balances the dynamic forces on the ship.

Figure 5 shows streamlines computed on a Series 60, Block 60 ship in a free surface. The vertical lines indicate the shape of the hull below the calm water line. The dashed line is the experimental free surface line. The solid line that nearly coincides with the dashed line is the computed free surface line.

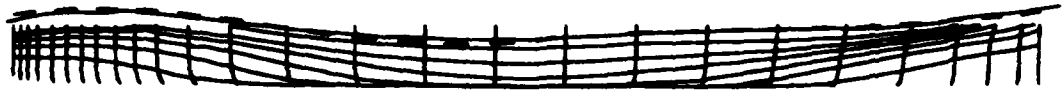


Figure 5 - Streamlines Computed on a Series 60, Block 60 Ship in a Free Surface

Vortex Behavior and Its Effects on Fluid Motions

Phenomena of Autorotation in High Angle of Attack Aerodynamics. Vortex behavior plays an essential role in time-dependent viscous flows past aerodynamical bodies at high angles of attack. In order to investigate such behavior, two-dimensional numerical solutions of the Navier-Stokes equations have been constructed to study the motion of rotating wings in a parallel flow. This investigation, completed during FY78, successfully explained the phenomenon of autorotation of wings perpendicular to a parallel flow. This knowledge is of importance in missile aerodynamics and aeroballistics.

The study of rotating wings demonstrated the power of computer simulation of fluid motion in the solution of certain flow problems as compared to experiments in the wind tunnel. In the special case of an autorotating wing, ball-bearing problems and limitations in the measuring techniques make it extremely difficult to obtain accurate experimental data on force coefficients, surface pressure, and surface vorticity. Numerical calculation, on the other hand, did not encounter such difficulties and revealed the subtle and intricate interplay of vortex shedding, boundary-layer hysteresis, and vorticity generation at the tips.

It was found that thin wings can autorotate with constant angular velocity if the rate of rotation is synchronous with vortex shedding. However, if one forces the wing to rotate at different angular velocities (for instance, by driving the wing with a motor), vortices will shed in an asynchronous way. The various types of vortex shedding are sketched in Figure 6. Figure 7 shows the similarity of flow patterns for an autorotating plate over a wide range of Reynolds number. This similarity results in an autorotation rate and in aerodynamic forces which are quite insensitive to changes in Reynolds number. Figure 8 shows half a rotation of a thick wing of elliptical cross-section. It is seen that, although the vorticity production near the tips of the thick wing is insufficient to allow autorotation, the patterns of both vortex generation and vortex shedding are similar to those for thin wings. Figure 8a shows streamline patterns for the body rotating relative to the observer, and Figure 8b illustrates the different patterns obtained when the reference frame is fixed to the body.

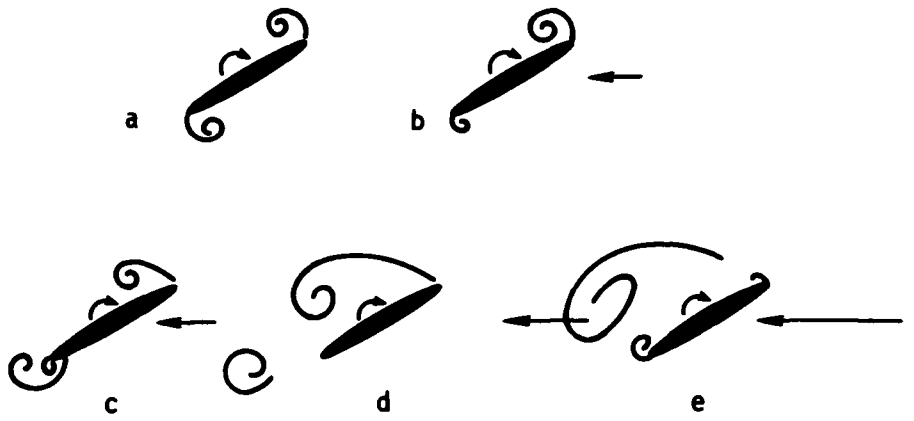


Figure 6 - Sketch of Vortex Shedding about a Rotating Plate

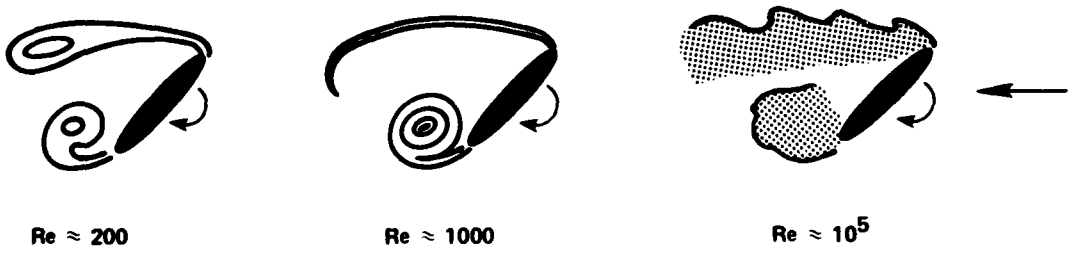


Figure 7 - Flow Patterns about an Autorotating Wing for Various Reynolds Numbers

Figure 8 - Sequence of Streamlines and Lines of Constant Vorticity about a Rotating Elliptical Cylinder in a Parallel Flow

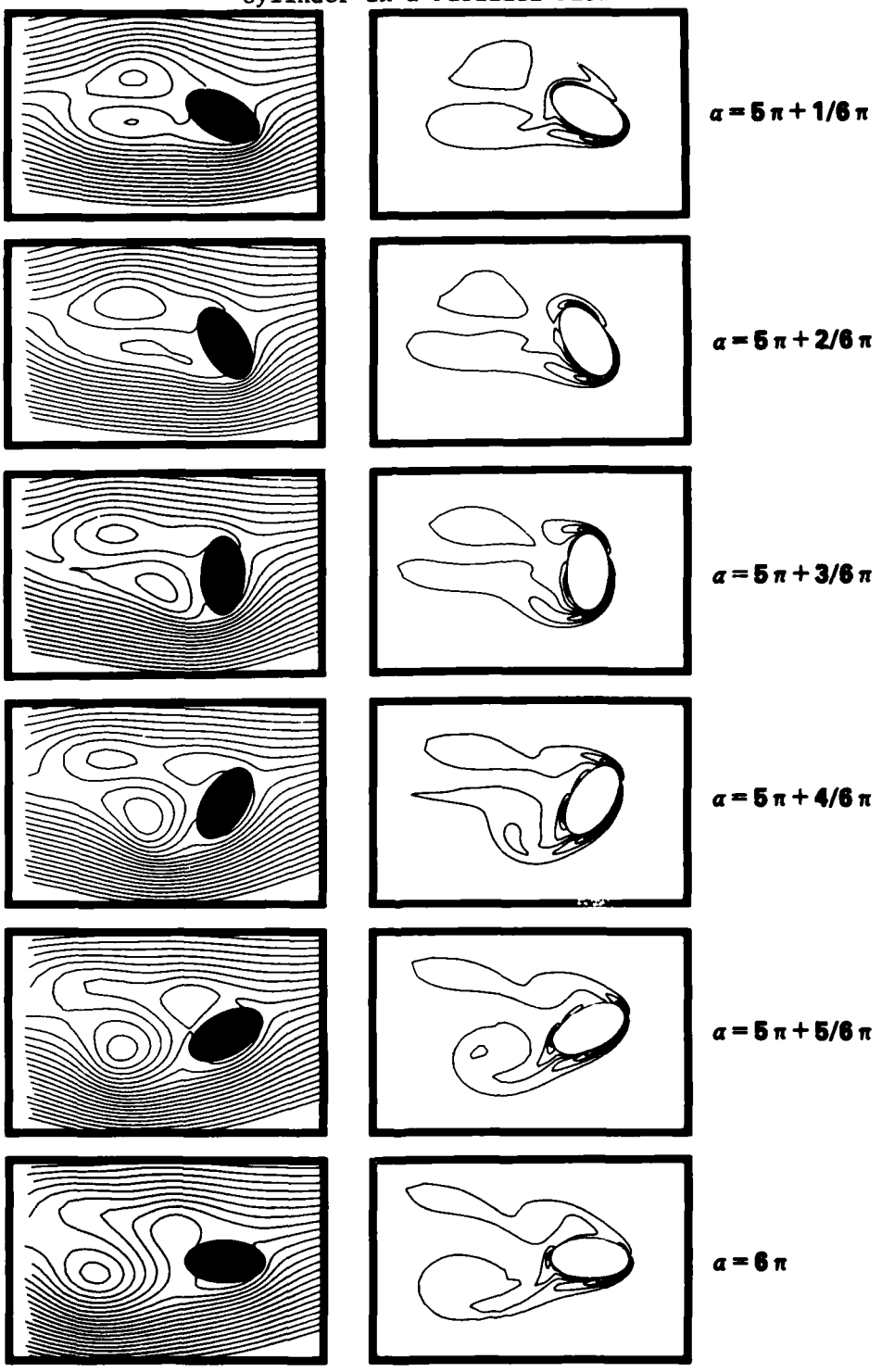


Figure 8a - Body Rotates Relative to the Reference Frame

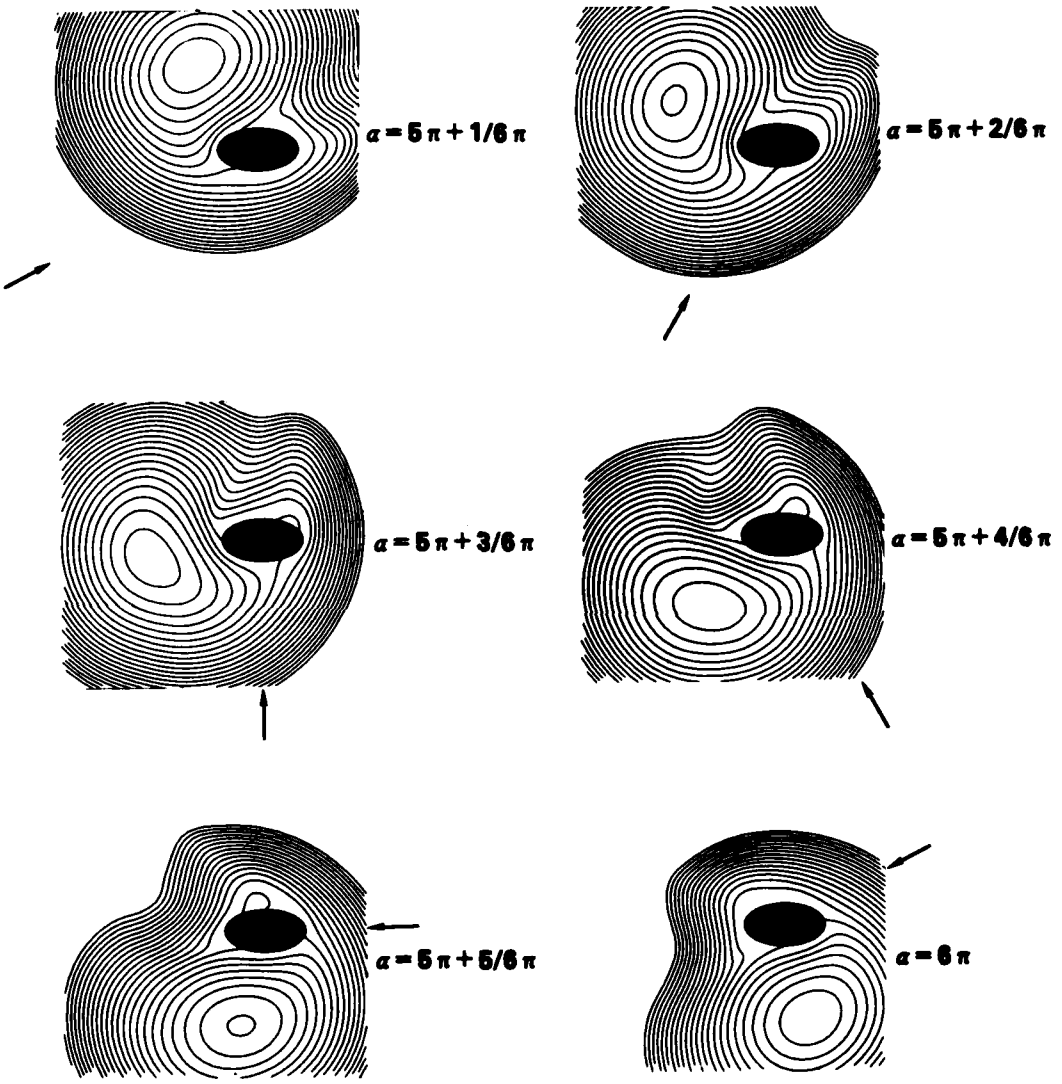


Figure 8b - Reference Frame Is Fixed to the Body

Vortex Shedding in High Reynolds Number Flows. In FY77 discrete vortex models were applied to the computation of the hydrodynamic noise generated by the roll-up of a free shear layer. During FY78 this work was extended to include the modeling of vortex layers generated in flows about bodies. A major goal is to remove, to the extent possible, the empiricism which has always been needed in discrete vortex programs. For example, previous models did not converge to an accurate solution as the number of vortices used to resolve the flow was increased. Thus the degree of resolution had to be chosen on the basis of comparison with experiments. A promising remedy is the so-called rediscretization of vortex sheets whereby the vortices on a sheet are repeatedly shifted such that equal spacing is presented. Such a rediscretization has been implemented, using B-spline subroutines developed by CMLD, in the computation of flow about a plate. After determination of the convergence and accuracy properties of this computational procedure it will be applied to vortex shedding from fins, hydrofoils, keels, and other appendages of significance in naval hydrodynamics.

Submarine performance provides an example of an application of vortex models. A discrete vortex program, used at McDonnell Douglas Corporation to compute the forces acting on a missile at an angle of attack, has been modified to compute the forces acting on a submarine in a steady turn. Effects of vortex shedding from the submarine sail have been included. Comparisons made by the Ship Performance Department have shown the computed forces to be in good qualitative agreement with experimental data. However, the program includes much empiricism and hence significant quantitative improvement in the predictions depends on the success of the efforts to advance the discrete vortex technology.

Mathematical Analysis to Increase Speed of Computer Solutions of Finite Difference Equations

Research was successfully pursued to accelerate the convergence of vector sequences generated in the iterative solution of large systems of linear algebraic equations such as arise in the finite difference or finite element solution of elliptic partial differential equations. For example, the solution of Laplace's equation is required to compute the potential

flow about submerged ship-like structures. With increasing complexity of the structural geometry, the number of nodal points required for accurate modeling increases, and hence the convergence of iterative portions of the computations becomes a more critical factor in terms of computer costs.

An experimental computer program has been developed to optimally choose and implement an acceleration method. This research has resulted in an acceleration method based on the known intimate relationship between the vector sequence and a geometric series in the iteration matrix. This method has consistently reduced computation time by a factor of roughly three for the canonical problem (Laplace's equation in a 10x10 square or a 10x10x10 cube) regardless of the finite difference equivalents used or of the basic iteration method employed.

Production Use of Contract Programs by Naval Laboratories

During FY78 CMLD continued to maintain and improve the Navy's master copy of the Transition Analysis Program System (TAPS). TAPS is a system of computer programs developed by McDonnell Douglas Aircraft Co. under contract to NAVSEA for aiding in the prediction of boundary-layer transition for axisymmetric and two-dimensional bodies. The Department continued to distribute the program and provide assistance to Naval and contract users. A second newsletter was published to announce further improvements and changes to the program.

The end of FY78 marked the completion of the TAPS project. A new component to compute the axisymmetric inverse potential flow was added and a final report was published by McDonnell Douglas. CMLD distributed the final report with a third and final TAPS Newsletter.

TAPS is one of the first Navy contracted computer programs for which funds were specifically allocated to perform in-house software maintenance and to give support to Navy laboratory users and Naval contractors. It is hoped that the benefits derived from this project by the Naval community will lead to further support of this nature for projects involving a future selection of fluid flow analysis programs.

Interactive Graphics Capability

Interactive Graphics Terminal. A Tektronix 4014 Interactive Graphics Terminal (Figure 9) was installed in a work room conveniently located for use by the Numerical Fluid Dynamics Branch staff. This terminal has a high speed telephone connection with the CMLD CDC 6000 computers, the NRL TI ASC computer, and the computers attached to the ARPA network. The terminal may be used to obtain quick paper plots of computer data as well as to serve as an interactive tool for problem analysis. A large digitizing tablet

Figure 9 - Tektronix 4014 Interactive Graphics Terminal

connected with the terminal may be used to produce computer data (point coordinates) from blueprints, drawings, or plotted curves in published articles. This last feature is very useful in quickly obtaining experimental data in a form for comparison with numerical results.

Interactive Data Display System. The Interactive Data Display System was developed for the CMLD CDC 6600/6700 comptuer to provide easy access to the terminal features. The Interactive Data Display System provides a command structure, user prompting, error recovery, and data management for a wide variety of function-oriented interactive graphics programs. Three such programs, PLOT QUICK, DIGIT, and SEAKEEPING, have been incorporated into the Interactive Data Display System.

PLOT QUICK is a fast, flexible, easy-to-use 2-D cross plotting system which permits the examination of 1-, 2-, or 3-D data arrays as generated by FORTRAN binary or formatted write-to-file statements. It accepts input from the DIGIT program or from the terminal keyboard. Publication quality plots may be produced either on the on-line hardcopy device or on any of the CMLD off-line plotters.

DIGIT, an on-line curve digitizing system, is an easy-to-use, powerful tool for digitizing two-dimensional curves. It allows any number of curves in any frames of reference to be digitized, edited, displayed, and saved for future use. The system has been used to digitize ship body plans for input to other programs and to digitize experimental data and publish curves for comparison purposes. DIGIT enables ship plans that used to require weeks of painstaking work to be digitized in a matter of days. Figure 10 shows a member of the Numerical Fluid Dynamics Branch using the Tektronix Graphics Tablet to digitize test data.

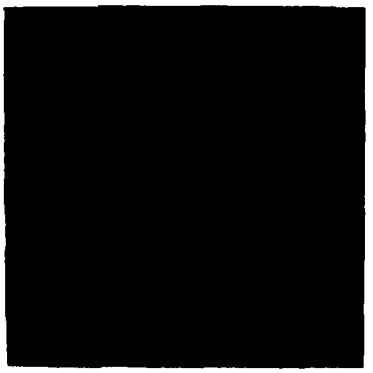


Figure 10 - Using the Tektronix Graphics Tablet
to Digitize Test Data

At the request of NAVSEC, CMLD developed SEAKEEPING, an interactive graphics system which generates contours from seakeeping data and displays them on 360-degree speed polar plots. The SEAKEEPING system has been enhanced to compute a performance assessment index (PAI) for a specified mission and to display the generated contours in five forms:

(1) about a motion limit for a specified ship, sea condition, and motion;
(2) at regular intervals for a specified ship, sea condition, and motion;
(3) as limits of various motions for a specified ship and sea condition;
(4) as motion limits of various sea conditions for a specified ship and motion; and
(5) as motion limits for a specified mission and ship.

The upgraded system also offers the capability to interactively modify the missions, the motion limits, and the polar grid, and to obtain directories of the data in the system. Figures 11 and 12 are examples of speed-polar plots produced by SEAKEEPING.

STRUCTURE AND MODELING OF TURBULENCE

Our study of the structure of aerodynamic and hydrodynamic turbulence in boundary layers, wakes, and jets includes the modeling of boundary layer turbulence and validation by appropriate coordination with experimental data, taking into account the difference in the structure of turbulence as perceived at different scales. The characteristics of turbulence in wind-tunnels and water-tunnels and in boundary layers are studied using experimental data analyzed by high-speed computing methods. The studies are conducted in cooperation with the National Bureau of Standards and the DTNSRDC Ship Performance Department.

Recent studies of boundary layer flow show that the production of turbulence is to a large extent due to the inrush of high momentum fluid into the region near the wall and to bursts of fluid from the wall region penetrating into the boundary layer. Another characteristic of boundary layer flow is that the large-scale motions, which retain some of their coherence and their identity in the turbulent flow, are interlaced and intermixed with the quasi-random small-scale turbulence. On the other hand it is believed that small-scale turbulence has a spotty or intermittent character in space and time in which the decreasing scales are increasingly more intermittent.

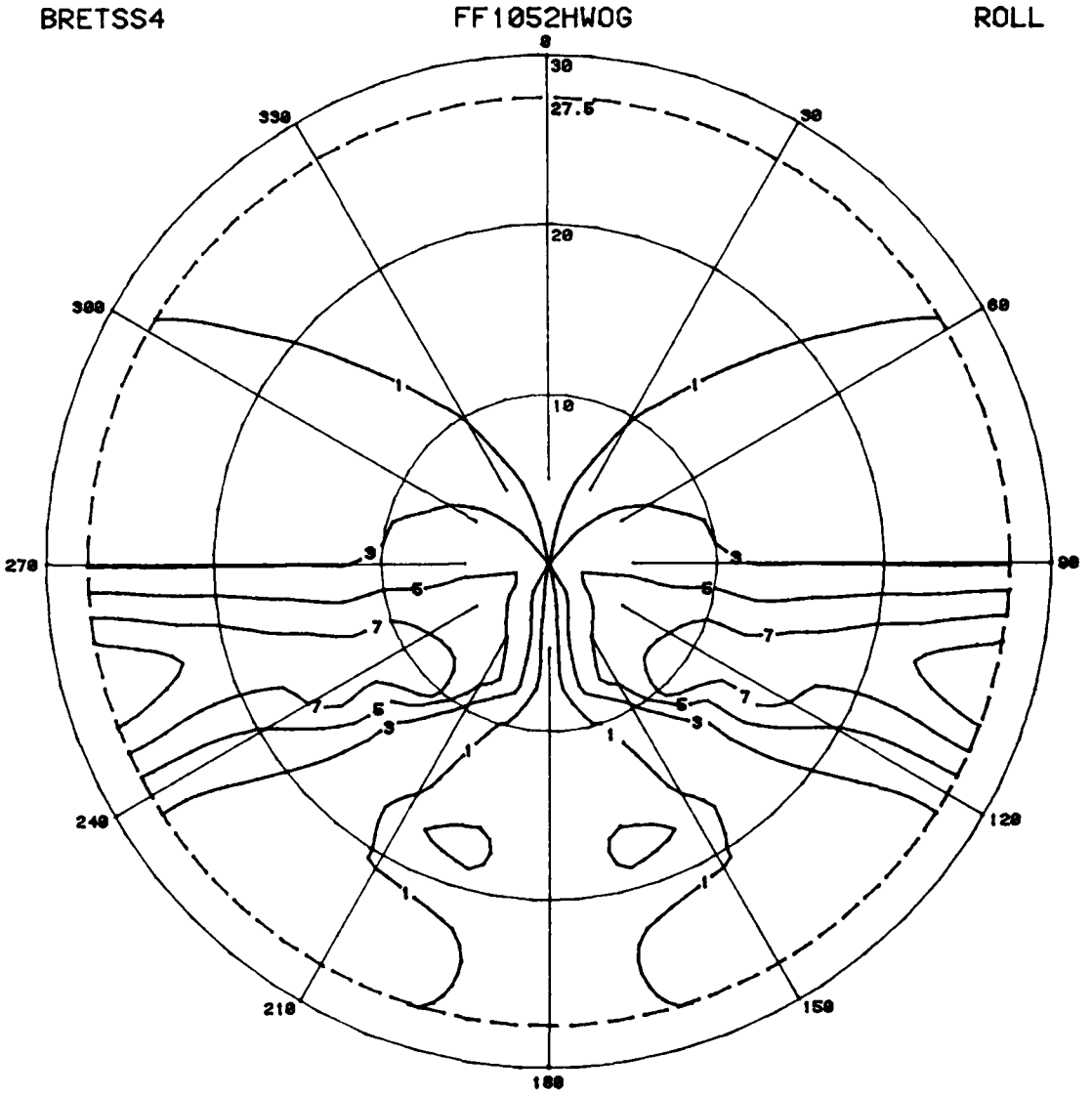


Figure 11 - Example of a Speed Polar Regular Interval Plot for the Motion Roll

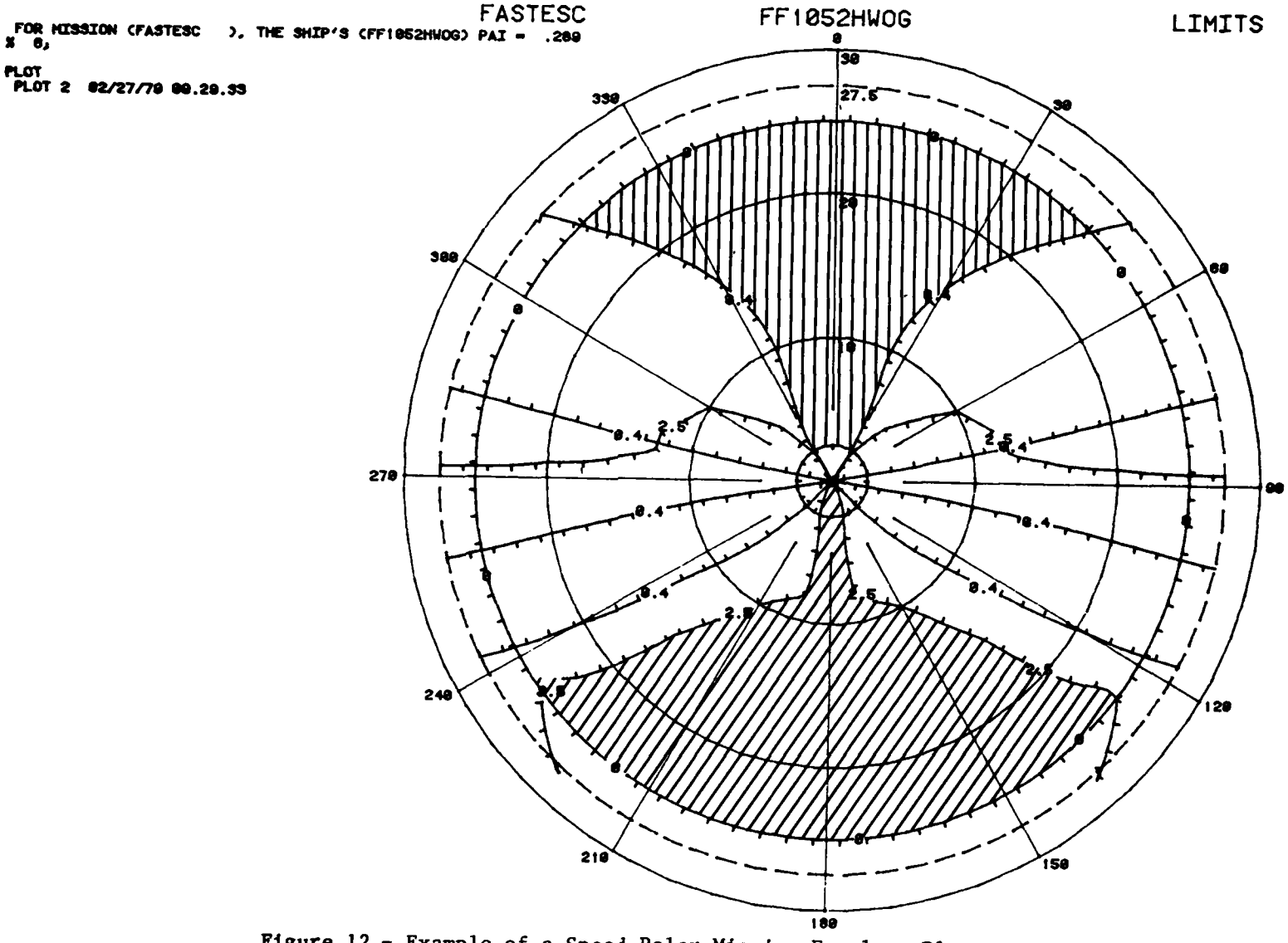


Figure 12 - Example of a Speed Polar Mission Envelope Plot

The complexity of the physical phenomena as presently understood makes modeling boundary layer turbulence quite complicated. A promising new approach to modeling uses three-dimensional time dependent partial differential equation models to analyze the large-scale turbulence and a considerably simpler steady model for small-scale turbulence. Separation of the large-scale and the small-scale processes will involve some difficulties and will require continuous validation by appropriate coordination with experimental data.

During FY78 a report was completed on an experimental comparison of grid turbulence in a wind-tunnel and a water-tunnel. Hot-wire and hot-film instrumentation combining analog and digital computing methods was used to measure higher-order correlations of the longitudinal component of turbulent velocity and higher-order moments of its gradient. A comparison of the latter was obtained for an extended range of Reynolds numbers without having to alter the flow geometry. The results presenting the even-order moments of the velocity gradients as a function of $n\ (n-1) \log R_\lambda$ (see Figure 13), where n is the order of the moment and R_λ the Reynolds number of turbulence, compare very well with the similar curve obtained previously for boundary layer turbulence. This comparison tends to indicate a universal equilibrium for the small-scale turbulence structure. This indication of equilibrium will contribute to justify the modeling of the small-scale structure by a more universal model than the large-scale structures.

It should also be noted that the curve presented in the figures indicates a combined effect of the Reynolds number of turbulence and the order of the even moments of the velocity gradients involving the product $n\ (n-1) \log R_\lambda$. Thus higher even moments are equivalent to the use of higher Reynolds numbers.

The flatness and skewness of longitudinal velocity gradients were investigated over an extensive range of Reynolds numbers of turbulence R_λ at various flow geometries. The results indicate that, while the flatness is a function of R_λ , the skewness does not show any appreciable changes for larger R_λ.

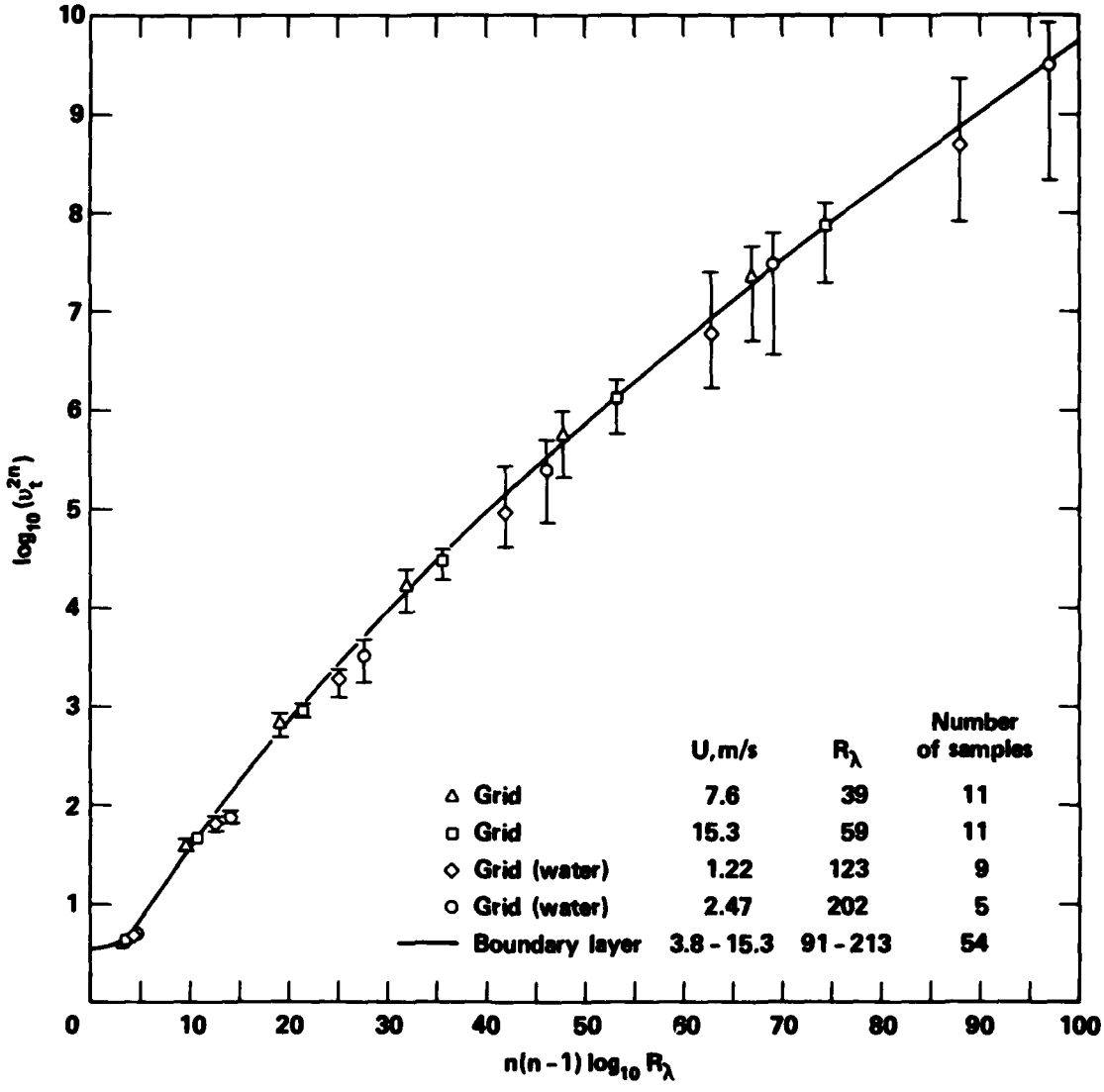


Figure 13 - Higher Order Even Moments for Turbulent Velocity Gradients up to Fourteenth Order

NUMERICAL STRUCTURAL MECHANICS

CMLD has continued to perform its two distinct functions in the area of numerical structural mechancis: (1) developing, maintaining, and fostering the use of efficient structural analysis computer programs and advanced methods to understand and predict the performance of naval ships, aircraft, and other related structures, and (2) serving as the Navy's focal point for maintaining the NASA Structural Analysis program (NASTRAN) on the Department's computers and providing training and consultation to other government agencies through the Navy NASTRAN Systems Office (NNSO). During FY78 major in-house research and development emphasis continued to be on fluid/structure interactions, numerical analysis, linear and non-linear structural analysis methods, and the development of a large scale integrated structural analysis system. The following paragraphs highlight the major milestones in individual efforts, including several special projects conducted during the year.

Fluid Structure Interaction

Underwater Shock. The Computation, Mathematics and Logistics Department and the Propulsion and Auxiliary Systems Department are developing shock design analysis methods for determining the linear transient responses of submarine hull structures and internal ship systems to nuclear underwater attack. This work, sponsored by the Defense Nuclear Agency (DNA), is an integral part of the Navy's total effort to develop an experimentally verified and practical dynamic design-analysis method for submarine hulls, end closures, appendages, and auxiliary and propulsion systems. The ultimate goal is to maximize the shock hardening of our submarine fleet.

One analysis approach couples the doubly asymptotic surface interaction fluid loading approximation (DAA) with the NASTRAN structural analysis computer program. After several successful applications on scale models, the approach was used to predict the shock response of the Submarine Shock Test Vehicle (SSTV) (see Figure 14), in cooperation with NAVSEA's recent SSTV Series II test program.

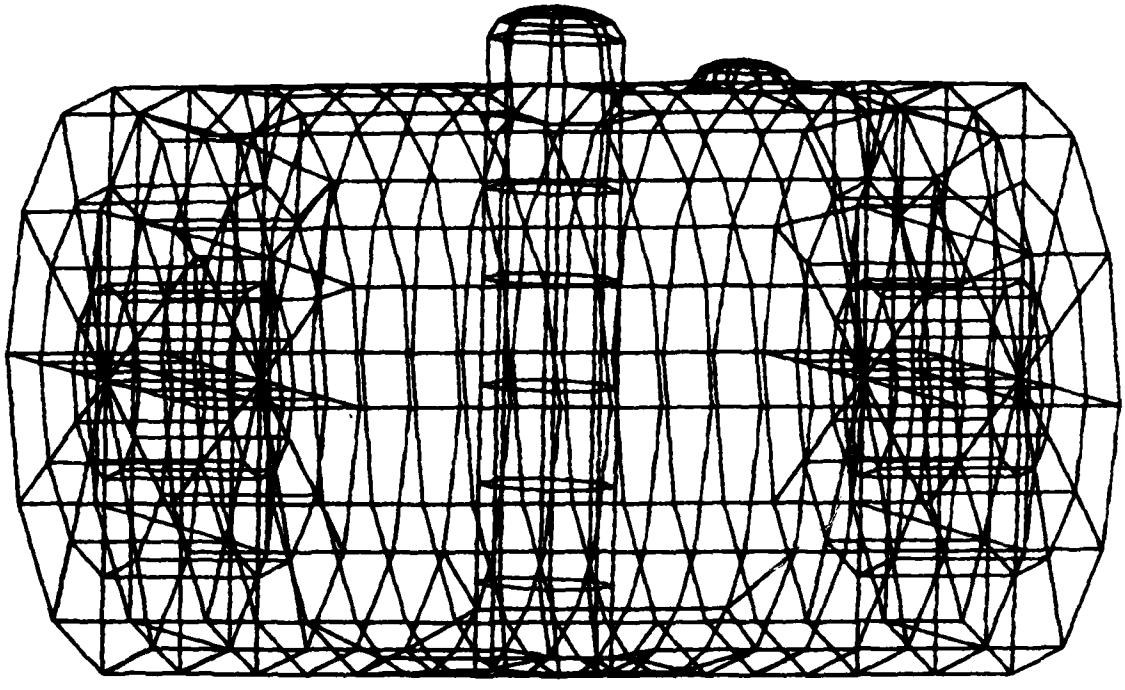


Figure 14 - Finite Element Model of Submarine Shock Test Vehicle (SSTV)

A second approach couples the NASTRAN structural analyzer with the Lockheed Underwater Shock Analysis (USA) code. Interface software was written by the Department (for NRL), and the NASTRAN/USA combination was successfully used for the first time this year to predict shock response of a submarine test model.

In addition, the shock response of a double-hull spherical shell was successfully analyzed by combining the NASTRAN/DAA capability with fluid finite element techniques previously developed. This work showed the feasibility of analyzing more realistic double-hull configurations in the future.

Acoustic Attenuation in Pipes. CMLD, in cooperation with the Propulsion and Auxiliary Systems Department, has been using finite element techniques to predict sound attenuation in pipes lined with viscoelastic materials (Figure 15). Several configurations of viscoelastic liners have been modeled with these methods. These configurations include liners of various dimensions, liners consisting of several sections, and liners containing cavities. Attenuations have been computed and compared with experimental

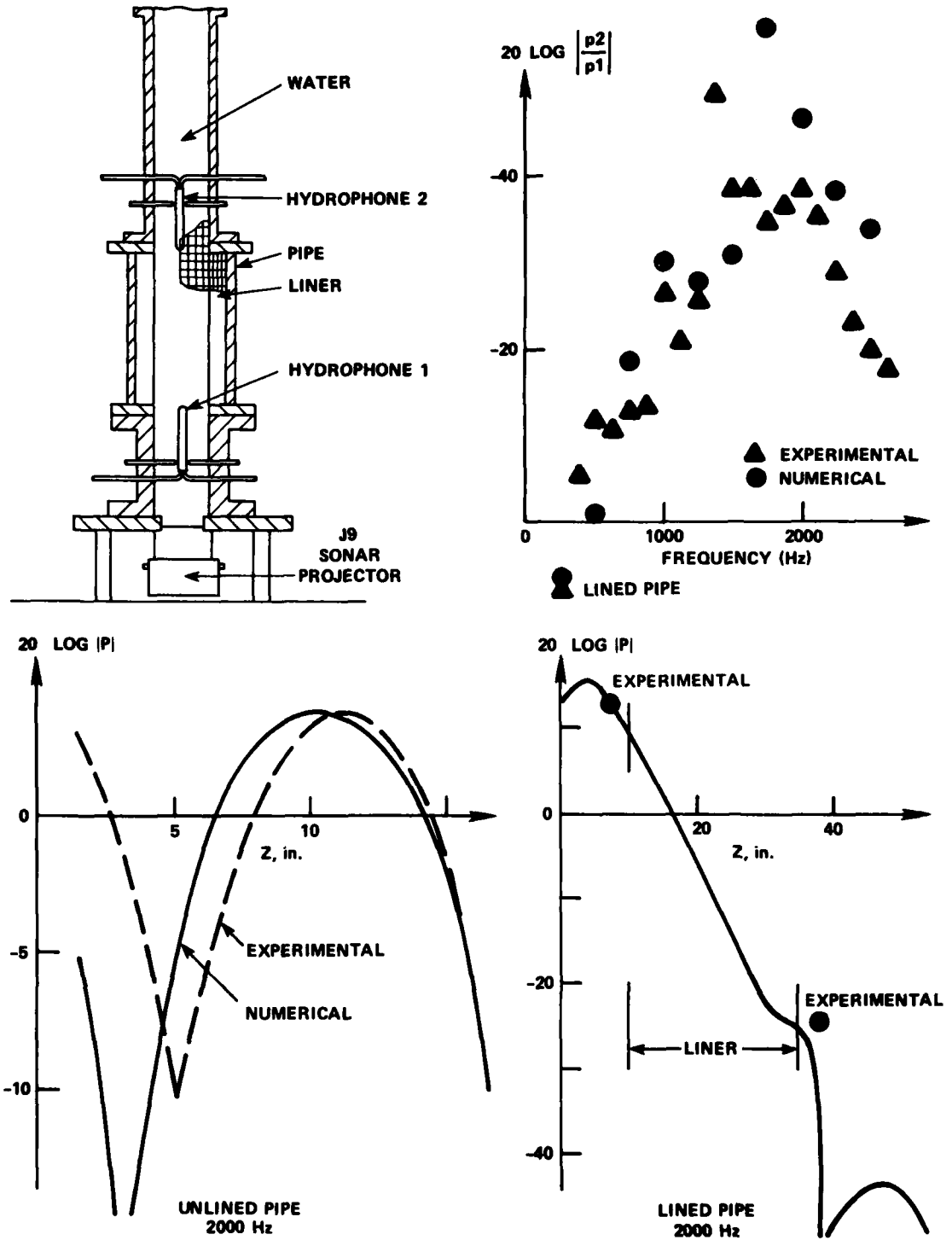
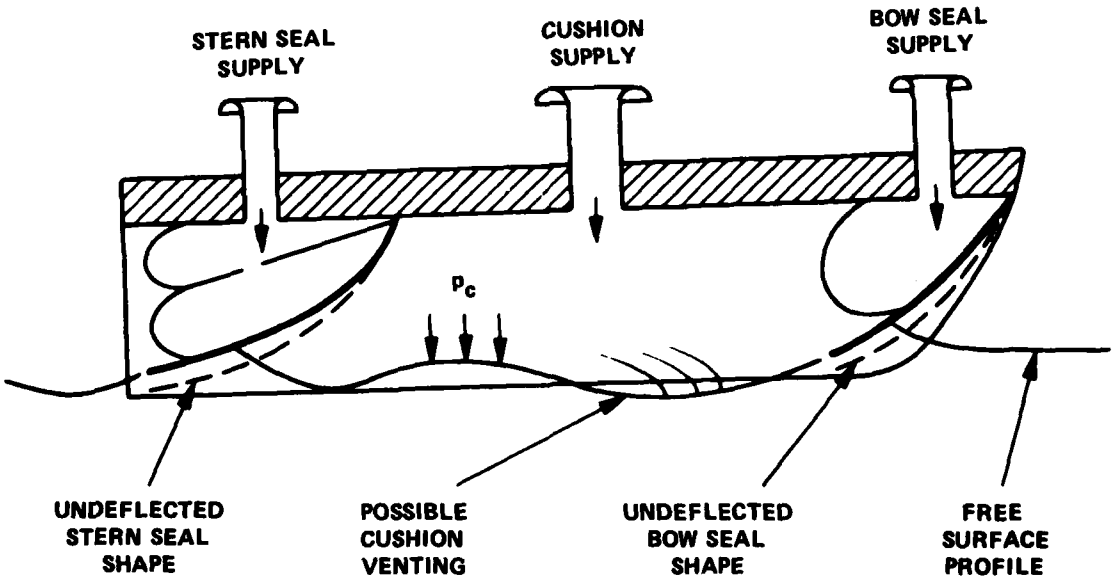


Figure 15 - Experimental Setup of a Lined Pipe as Modeled Using Finite Elements

results. The comparisons show that a fair degree of correlation holds between the two sets of results. While these results are encouraging, they also show a good deal of work remains before a satisfactory analysis can be obtained.

Free Surface Flows. A finite element method using NASTRAN has been developed to compute the pressure distribution on a rigid body planing on a free surface. The method also gives the shape of the free surface produced by the planing body. Thus the lift, drag, and elevation of the planing body are obtained. Results were compared with those of another numerical method and showed good agreement. When extended to include the elasticity of the planing body, this method can be used, for example, to compute the lift, drag, and deflection of a skirt on a surface effect ship (Figure 16).



TYPICAL LAYOUT OF SIDEWALL CRAFT

Figure 16 - Schematic Drawing of a Surface Effect Ship Showing the Flexible Skirts (Bow and Stern Seals) Planing on a Free Surface

Modeling of Structural Seaworthiness. A capability to determine the structural response of a surface ship to an underwater explosion has been added to the computer program ROSAS (Response Of a Ship At Sea). The digital program ROSAS, which simulates the dynamic response of a surface ship to a seaway, is being developed jointly by CMLD and the Structures Department.

General Bending Response. Consultation and guidance services to Navy and private industry on usage of the General Bending Response computer program (GBRP) have continued. A particular example of such consultation in FY78 involved an application of GBRP's transient response capability to numerically predict acceleration levels which might occur in a tanker hull due to collision.

The recently developed (FY77) computer program, GBREXT, patterned after the General Bending Response Program, was applied to the calculation of the undamped frequency response of coupled longitudinal-flexural motion for two vessels: USS GEORGE WASHINGTON (SSBN 598) submerged with assumed values of center of mass offsets along the hull, and USS STURGEON (SSN 637) for both in-air and submerged conditions and with offsets specified in the vessel's weight control report. The hull and propulsion shaft were idealized in both cases as elastically connected nonuniform beams. The calculated results for each hull compared favorably with those obtained using the NASTRAN computer program.

Integrated Structural Analysis System

CMLD, in cooperation with the Structures Department, is developing an automated integrated system for finite element analysis which gives the engineer computer support throughout the entire analysis sequence. This system, called Structural Analysis by Generalized Integrated Graphics (STAGING), is being developed under a joint program with the Air Force Flight Dynamics Laboratory. STAGING uses interactive computer graphics to give the engineer a "window" with which to view the model as it is being created and to see the results after the analysis program has been run.

DTNSRDC's primary responsibility in the joint effort is to provide computer support for model creation. One significant step in this direction has been the development of the GPRIME geometric language, which permits efficient description of the structural geometry. In the past year many new features have been added to GPRIME, the most significant being data generators which reference GPRIME geometry.

Traditionally, the usefulness of automatic data generation programs is limited by the fact that most practical problems have unique features which cannot be accommodated by automatic schemes. GPRIME's model generation capability goes beyond the usual mesh generation programs by providing efficient tools for tailoring the automatically generated models to meet those special requirements. These tools permit interactive changes to the finite element model and interactive creation of three-dimensional points using two-dimensional graphics screens or digitizing tablets. The key to efficient interactive processing is the availability of GPRIME geometric definitions which serve as references for three-dimensional information. Figure 17 illustrates steps in the interactive modification of an automatically generated mesh to accommodate a hole.

An effective and inexpensive hidden line removal technique has been developed to aid in interactive model creation. This technique, which is based on the "Z-buffer" principle often used for television-type displays, can be used with any graphic output device and can handle collections of complex surfaces. This capability is illustrated by the hull model in Figure 18. Often hidden line removal can eliminate the ambiguity in detailed plots as is evident in Figure 19.

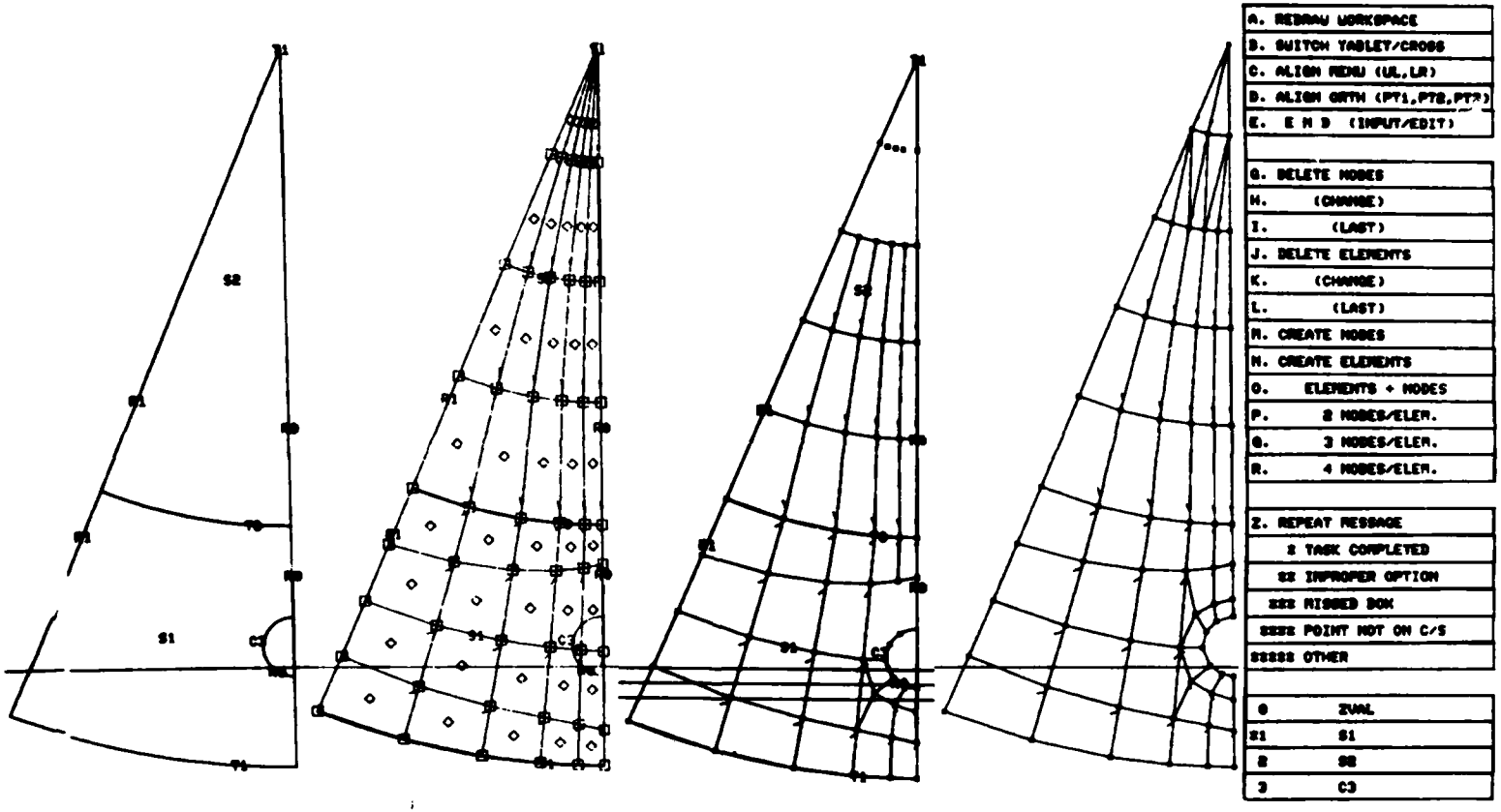


Figure 17a - Reference Geometry

Figure 17b - Automatically Generated Mesh

Figure 17c - Optional Description with Modifications

Figure 17d - Final Model

Figure 17 - Positioning a Hole in a Finite Element Model

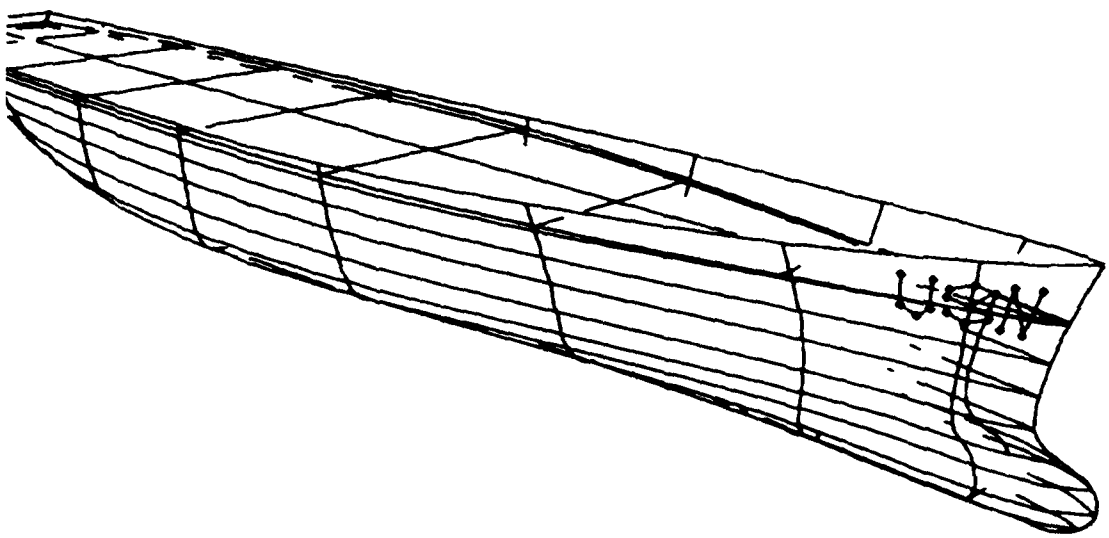


Figure 18 - Hull Model with Hidden Lines Removed

Figure 19 - Hull and Water Surface

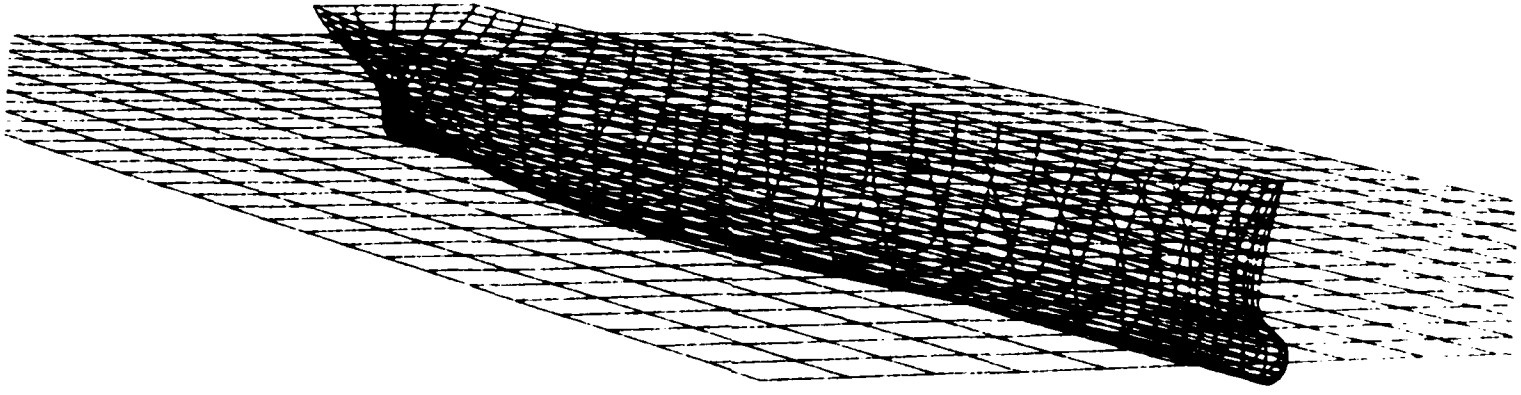


Figure 19a - All Lines Drawn

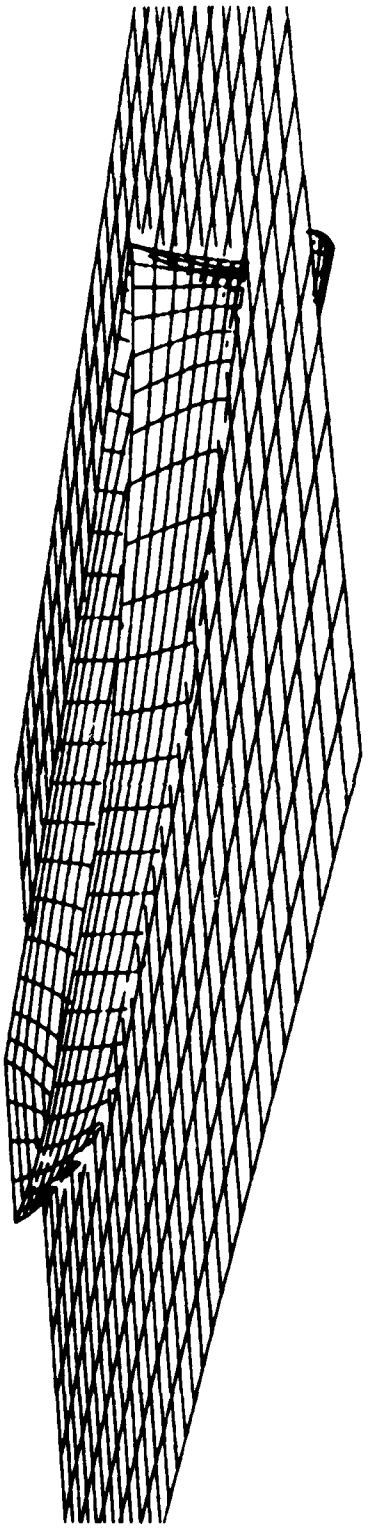


Figure 19b - Hidden Lines Removed

Numerical Analysis

One of the long range efforts in CMLD has been to investigate and develop efficient numerical techniques required in the solution of large structural analysis problems. Under this project, an investigation of several computer programs for the in-core solution of large order sparse systems of simultaneous linear equations was completed and documented. An investigation of a problem which involves finding an approximation to a least-squares solution of a system of simultaneous linear equations is now under way.

The Department has also been active in the development, evaluation, and implementation of algorithms which re-order sparse matrices to achieve reduced matrix bandwidth and wavefront. One of the consequences of this effort has been the collection of a versatile set of engineering test problems, which will be formally made available to the research community in a forthcoming journal article. The collection apparently fills a void, since seven requests for the collection have been received this year in advance of publication.

Linear/Nonlinear Analysis

Nonlinear Analysis. A structural analysis capability for NASTRAN which takes into account nonlinear geometrical effects for plate and beam finite elements was developed during FY77. During FY78, the major time-consuming operations of that capability were reduced by 15% by performing some computations analytically rather than through numerical integration.

Specifications were written and three small contracts were awarded to Grumman Aerospace Corporation (GAC) for the inclusion into NASTRAN of an initial nonlinear material capability. Such a capability had previously been developed by GAC for implementation into their NASA-funded structural analysis program PLANS.

Stress Concentration (Optimization). In FY77 a procedure was developed to determine, for a given opening in a plate structure, the amount and distribution of reinforcing material required to keep the sum of principal stresses unaltered with respect to the plate without an opening. In FY78, this procedure was modified to include the design criteria for constant circumferential strain around the opening.

Navy NASTRAN Systems Office

FY78 marks the 10th anniversary of the Navy NASTRAN Systems Office (NNSO) whose mission has been and continues to be the development, maintenance, and fostering of computer methods and programs for a broad class of structural analysis and design problems of Navy interest.

The main vehicle for carrying out NNSO's mission has been the NASA sponsored structural analysis program NASTRAN and a number of CMLD developed pre- and postprocessors for NASTRAN.

For the past 10 years, NNSO has been providing engineers in the Navy and other government agencies with training in the use of finite element methods and NASTRAN for their respective needs. Twenty-two formal one-week NASTRAN user's courses have been given to date, graduating a total of 610 students. Ten of these courses were presented at DTNSRDC; the remaining twelve were given at various government installations throughout the country at the request of those installations. In addition to formal courses many engineers took advantage of individual tutoring available from NNSO.

The most sought-after activity of NNSO is the consultation provided to engineers of the Navy and other government activities in the area of structural analysis, design, and computer usage. To many engineers, the opportunity to discuss problems arising in their technical work and to capitalize on the experience of other is invaluable.

In the last 10 years NNSO has contributed many improvements and innovations to the NASTRAN program. Some of the innovations were requested by the users, others were initiated within NNSO. Specifically, in FY78, the following tasks were accomplished:

- taught one-week NASTRAN beginners' course at DTNSRDC attended by 34 students from various Navy, Army, Air Force, and NASA installations;
- inserted two-dimensional quadratic isoparametric membrane finite element into NASTRAN Level 17 for use in an analysis of SWATH; and
- general NASTRAN consultation, including a significant amount during an analysis of the TOMAHAWK cruise missile, performed by NSWC/WO.

Special Projects

Computer Shelter. The Naval Surface Weapons Center (NSWC)/Dahlgren is responsible for providing a portable computer shelter for combat data processing and communications. In FY77, CMLD provided NSWC/Dahlgren with static and dynamic analyses of the shelter for the specific loads. In FY78, the same analyses were performed on a modified design of the shelter which was based on the earlier analyses. Figure 20 shows the shelter and its first bending mode, as computed.

Electromagnetism. CMLD is assisting the Propulsion and Auxiliary Systems Department in numerically determining the magnetic field about a ferromagnetic body. The solution to this problem has usually involved the magnetic vector potential. However, a paper by Zienkiewicz et al. indicates a new method using a magnetic scalar potential, resulting in faster computer times and elimination of most boundary condition problems. We have implemented this method into NASTRAN, and Figure 21 shows some qualitative results. The righthand side of Figure 21 shows the magnetic field produced when a ferromagnetic cylinder is placed in a uniform magnetic field. The lefthand side shows the NASTRAN finite element model and the results in which only the top half of the cylinder is modeled. Figure 22 pictures a NASTRAN finite element model of a sphere in a uniform magnetic field. Figure 23 shows that the comparison between the NASTRAN solution for the sphere and the analytic solution is excellent.

Figure 20 - Computer Shelter

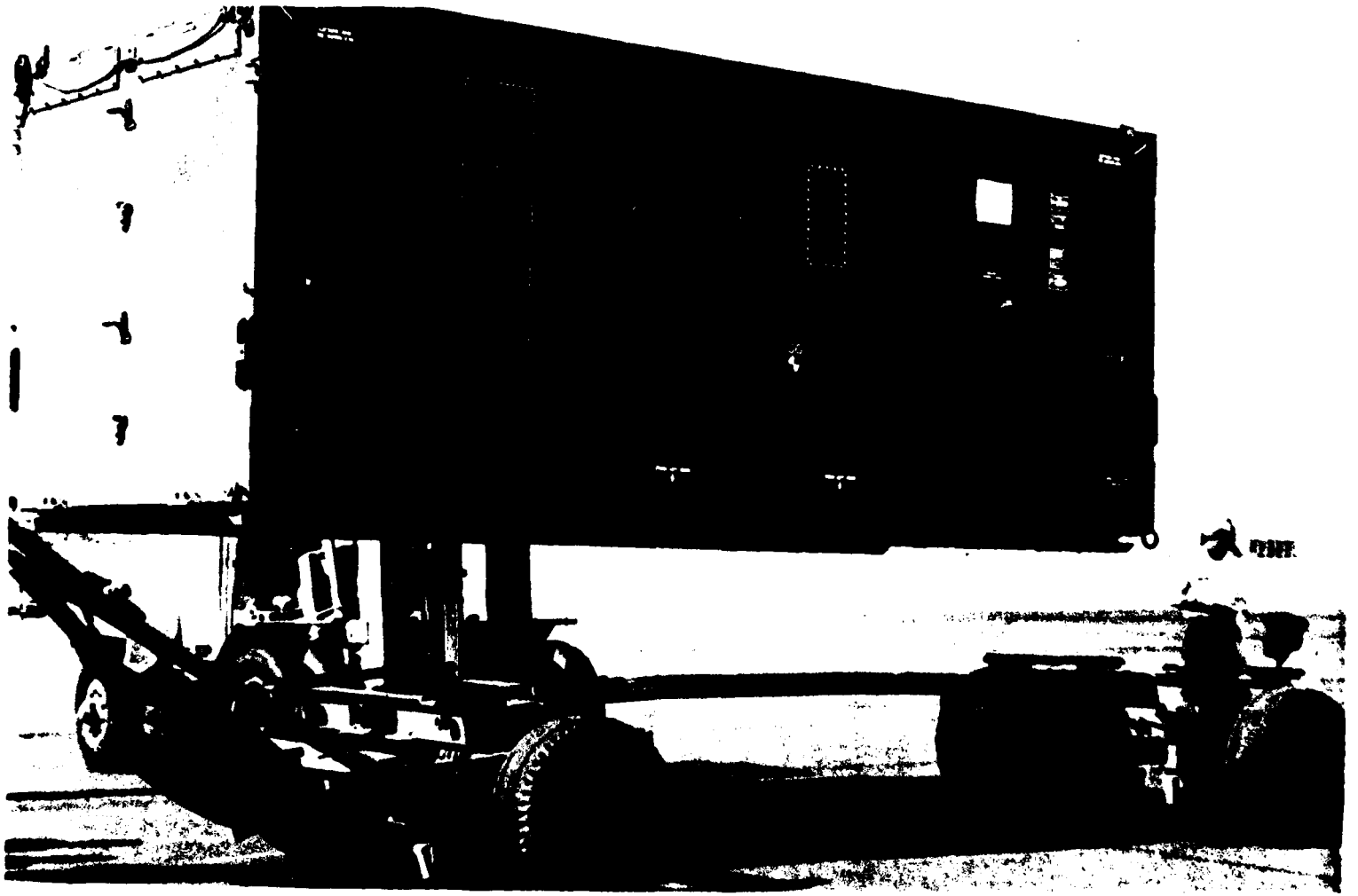


Figure 20a - ADP/Communications Shelter

Figure 20 (Continued)

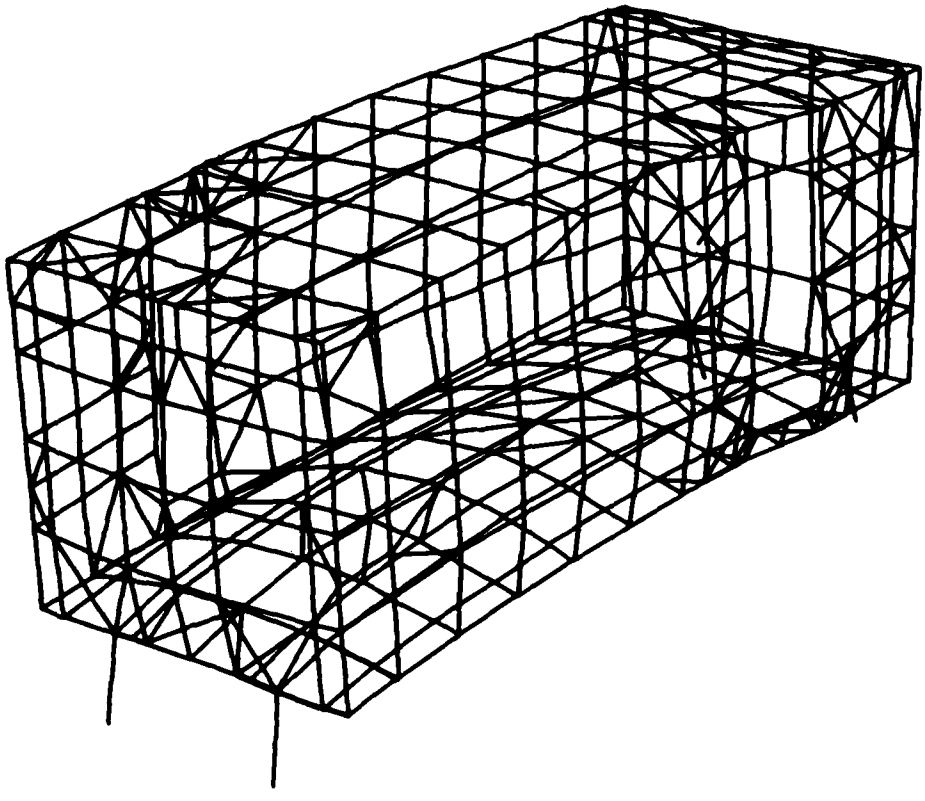


Figure 20b - Fundamental Vibration Mode of the Shelter

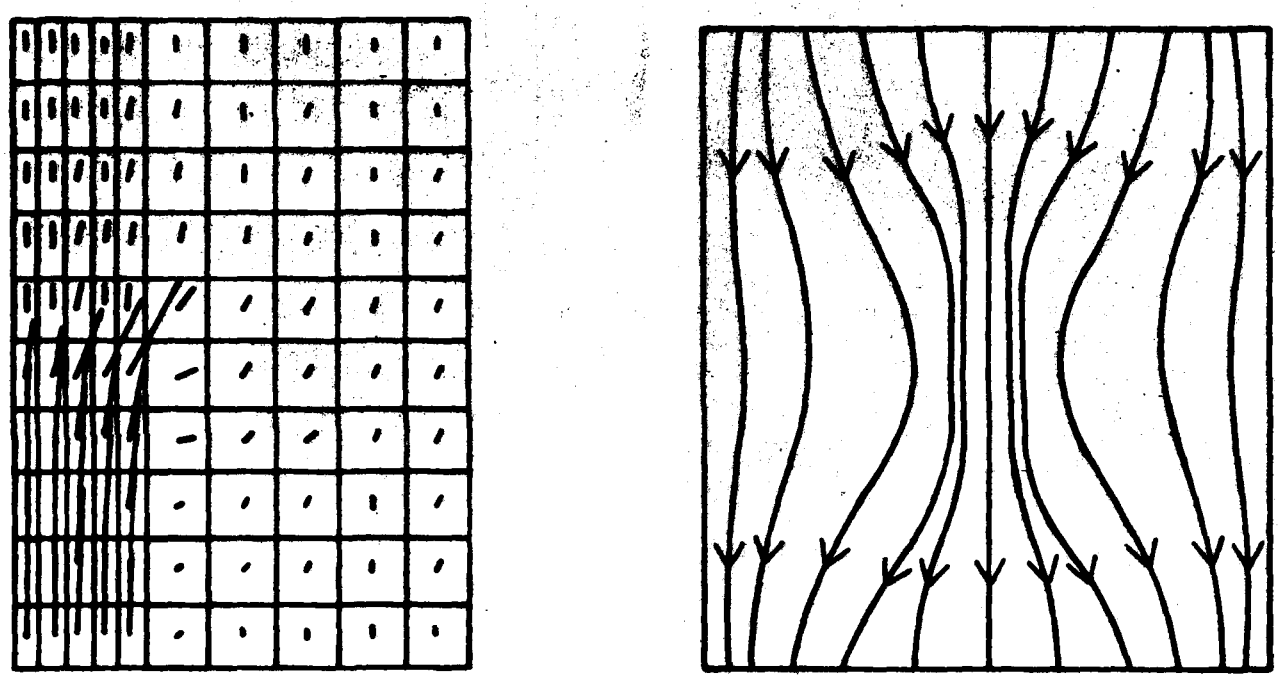


Figure 21 - Ferromagnetic Cylinder in a Uniform Magnetic Field

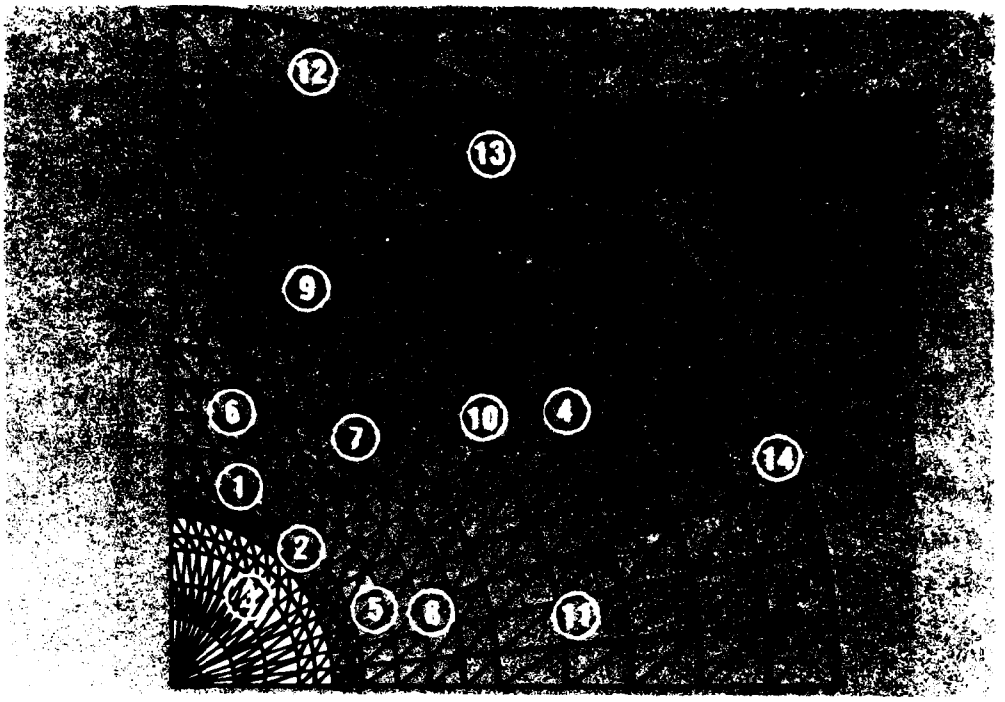


Figure 22 - Ferromagnetic Sphere in a Uniform Magnetic Field--Finite Element Grid

DATA POINT	ANALYTIC SOLUTION		NASTRAN SOLUTION		DEVIATION	
		deg		deg	percent	deg
1	0.396 TESLA	56.3	0.396 TESLA	59.0	0.0	2.7
2	0.843	52.7	0.840	53.5	0.3	0.8
3	1.488	0.0	1.537	0.0	3.3	0.0
4	0.523	86.9	0.527	87.1	0.7	0.2
5	0.941	76.5	0.921	76.3	2.1	0.2
6	0.417	79.2	0.409	80.6	1.9	1.4
7	0.571	74.6	0.579	74.5	1.5	0.1
8	0.705	83.7	0.697	83.6	1.1	0.1
9	0.479	86.7	0.483	86.8	0.7	0.1
10	0.526	85.3	0.532	85.4	1.1	0.1
11	0.566	88.3	0.562	88.5	0.7	0.2
12	0.492	89.3	0.499	89.3	1.5	0.1
13	0.499	88.6	0.505	88.6	1.3	0.0
14	0.516	89.1	0.523	89.0	1.6	0.1

Figure 23 - Ferromagnetic Sphere in a Uniform Magnetic Field--Results

COMPUTER SCIENCE AND INFORMATION SYSTEMS

The Navy has very large information (data) processing requirements to support its fleet logistic operations, the modernization of its ship design methods, and many other programs which depend on the availability of reliable data. For example, the Naval Supply System operates several very large data base installations which will be converted to new generations of hardware/software in the next decade. At the same time, the Computer Aided Ship Design and Construction (CASDAC) program needs the technology in information processing and data management to achieve its data base processing objectives. These and other Navy programs need to be able to plan large system developments on a more certain basis than has been possible in the past. The large investments involved in such systems demand a more disciplined approach to the selection and use of the technology. Concurrently, there is a considerable impetus to increase the use of automation within the fleet itself to support the control of logistics functions which keep the fleet operational. This application of technology requires innovative approaches because of the shipboard environment which is far less controllable than the normal ashore ADP facility. The Department's computer science and information systems research program has been structured to respond to the Navy's needs for technical direction in the application of this rapidly changing technology. To meet these needs, the program seeks to advance the state-of-the-art in ADP technology and information systems research, and to evaluate and exploit current computer technology to solve the Navy's logistics, acquisition, management, and engineering problems.

LOGISTICS INFORMATION SYSTEMS TECHNOLOGY

Information Systems Design for Navy Logistics Systems (ISDNLS)

The objective of this ISDNLS project, begun in FY75, is to develop an improved methodology for developing responsive and reliable information processing systems for the Navy's logistics community and to improve user satisfaction through more thorough and realistic requirements analysis and

more accurate prediction of system costs and performance. The design methodology being developed will greatly reduce the number of internal inconsistencies in user requirements, simplify the investigation of alternative designs, provide tools for performance prediction, simplify the maintenance and enhancement of an information system, and provide current documentation for the information system.

The evolutionary cycle of a typical information system is shown in Figure 24. The volume and complexity of information increases greatly at each stage from requirements analysis to implementation; errors should therefore be detected and corrected as soon as possible, while the consequences of changes are relatively easily foreseen.

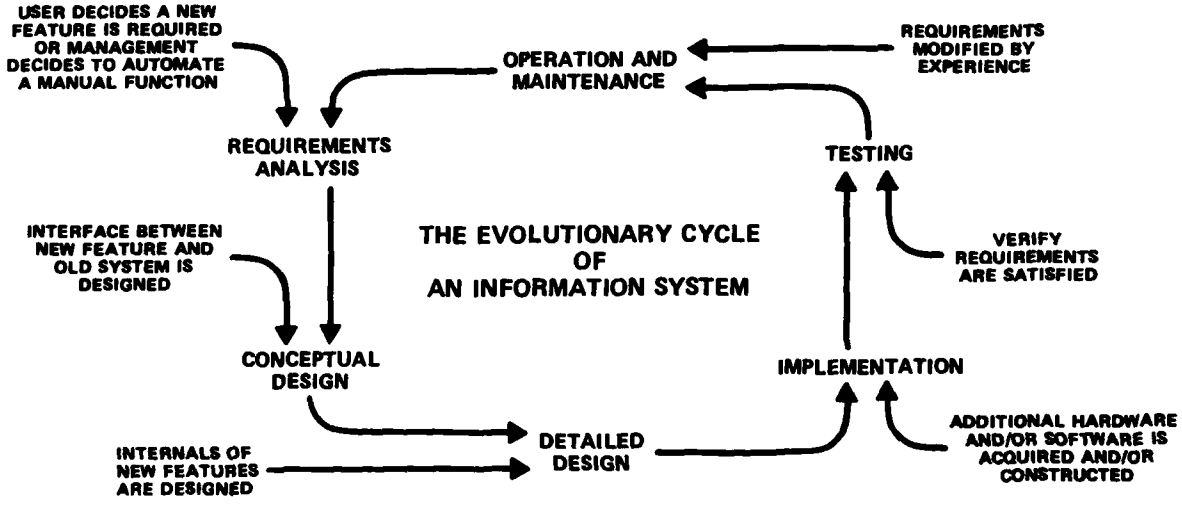


Figure 24 - Evolutionary Cycle of a Typical Information System

The first major thrust of the ISDNLS project has been toward the development of a methodology for requirements analysis, conceptual design, and detailed design, in order to reduce the risk that errors in these initial stages will necessitate costly reprogramming at later stages.

During FY75 and FY76, detailed goals and overall design of the ISDNLS methodology were formulated. Studies were made and computer programs acquired in the areas of requirements analysis and conceptual design, distributed data bases, generalized data base management systems, data base design, and mass storage technology. A reference library on these and related areas is now composed of two thousand documents.

The most comprehensive tool available for requirements analysis and conceptual design is the Problem Statement Language/Problem Statement Analyzer (PSL/PSA) developed by the University of Michigan for their Information System Design and Optimization System (ISDOS). PSL/PSA provides computer assistance for recording a system design, eliminating internal inconsistencies, and producing a variety of up-to-date documents describing the system from different points of view (see Figure 25). Only those aspects of the evolving information system which are of immediate concern are included in any one document. Irrelevant details are suppressed, yet the different views of the system are up-to-date and consistent. The ISDNLS project has become an affiliate of the ISDOS research project, has installed PSA on the DTNSRDC CDC 6700 computer, and is using PSL/PSA as the foundation of its design methodology (Figure 26).

An evaluation of the use and effectiveness of PSL/PSA during the conceptual and detailed design phases was begun in FY7T. The intent was to determine areas of PSL/PSA which should be strengthened. During FY77 an automated, annotated bibliography and initial characterization of data descriptions were compiled. That characterization has been refined by a study of several existing data base design methodologies and data dictionaries. Consequently, PSL/PSA enhancements were recommended during FY78. These enhancements would provide a greatly increased ability to specify how processes are to be performed, rather than what the processes should do. Possible ways of implementing these enhancements will be studied during FY79.

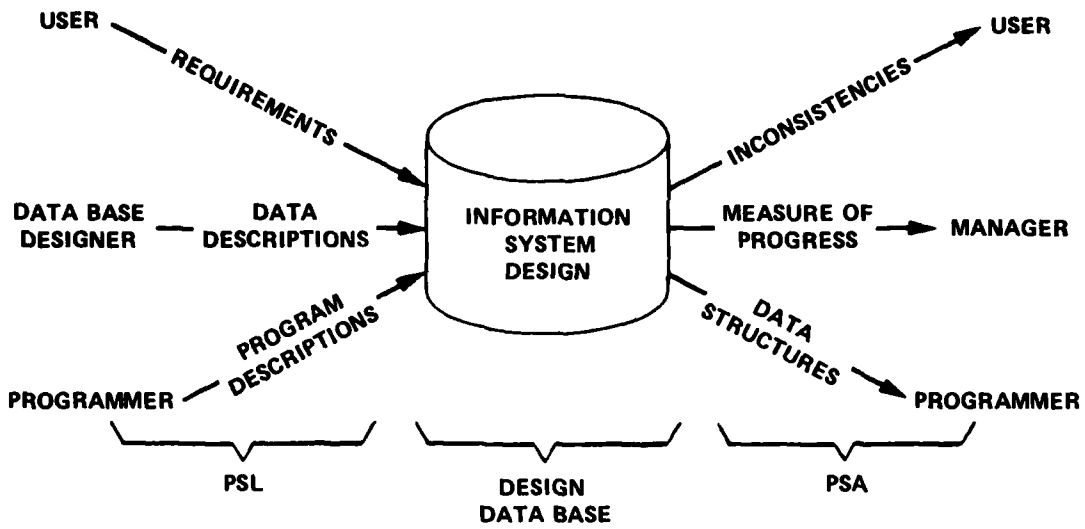


Figure 25 - Requirements Analysis

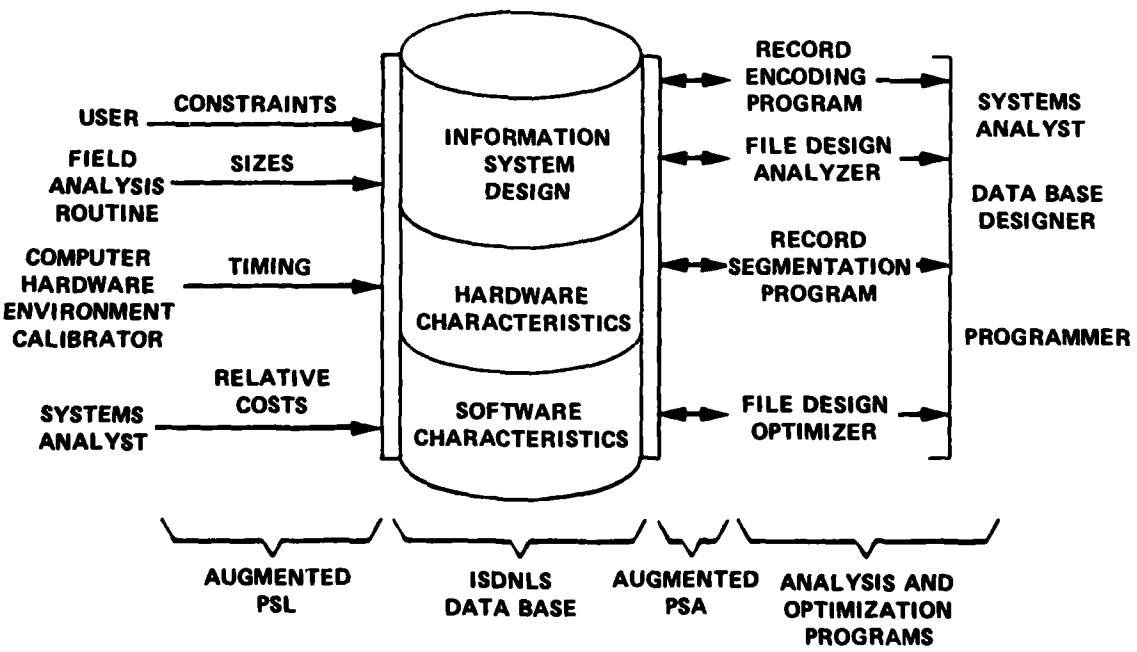


Figure.26 - Data Base Design

The second major thrust of ISDNLS has been the development and integration of tools for data base design and optimization. Currently available tools include the Field Analysis Routine, Computer Hardware Environment Calibrator, Record Encoding Program, Record Segmentation Program, File Design Optimizer, and File Design Analyzer. All programs except the File Design Analyzer were developed and integrated into a common package during FY76 and FY77. During FY78 the last three programs were provided with an interface to the PSL/PSA data base, which will automatically provide the various hardware data base and query parameters required as input to the design programs (Figure 26). Data base design tools will be further developed in FY79.

The third major thrust of ISDNLS will be toward the development of tools for simulating information systems and managing their development--i.e., preliminary tools for assisting in the implementation phase. This effort will begin in FY79.

ADP Security

The intent of the Department's ADP security program is to exploit technologies that support ADP system security. The initial major tasks in this program include development of secure data base management systems (Back-End Systems) and remote access control systems. Under this program CMLD will test and evaluate new technologies related to these tasks and determine their relevance and applicability to the Navy Supply Systems ADP environment.

The Secure Data Base Management System (DBMS) effort was begun in FY77 to test and evaluate a new DBMS concept, the back-end DBMS concept (see Figures 27 and 28). Under this concept the DBMS is removed from the mainframe central processing unit (CPU) and placed in a dedicated minicomputer. Within this structure the mass storage devices and data bases are under the control of the mini-based DBMS; there is no direct link between the host CPU and the data base storage. In the host computer, application program requests for data are passed to an interface program which is a message processor. The interface passes data requests to the back-end mini/DBMS and passes the corresponding data back to the application programs.

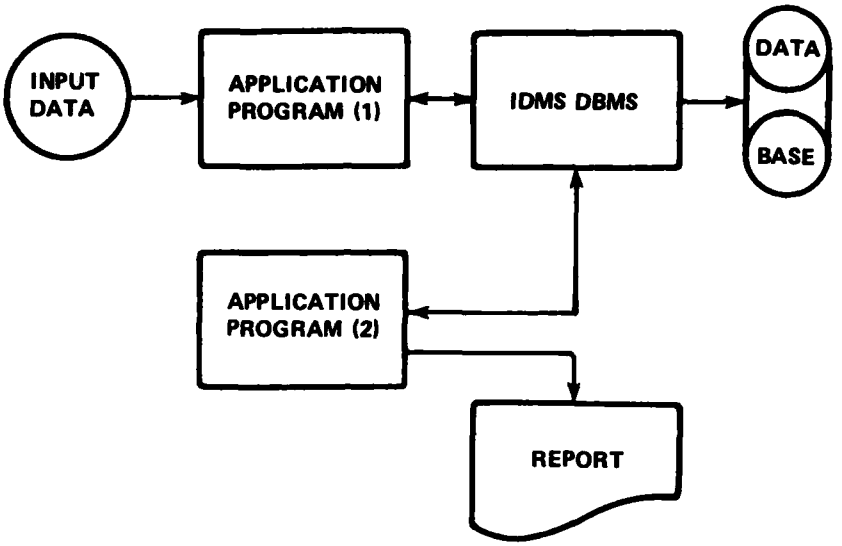


Figure 27 - Normal DBMS Environment

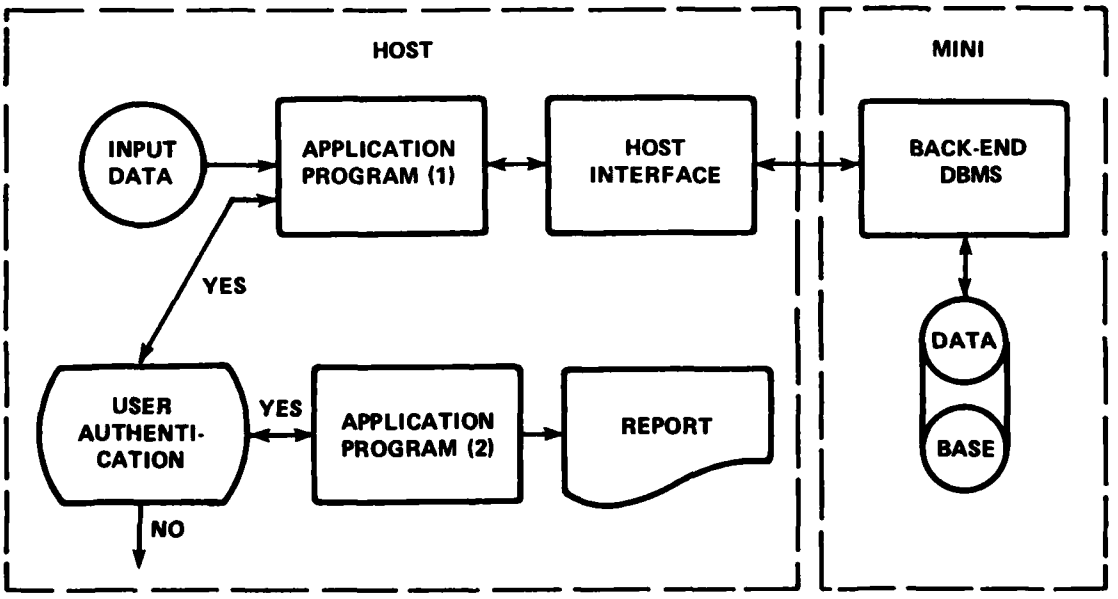


Figure 28 - Back-End DBMS Environment

This configuration provides several benefits. The mini-based DBMS software is physically secure from penetration and misuse by application programs. The data base can be accessed only by the back-end system (no direct link between data base and host CPU), and therefore applications programs cannot circumvent the DBMS to make unauthorized accesses to the data base. Because the DBMS is in a separate CPU, DBMS operations execute in parallel with applications programs in the host CPU, providing improved efficiency and throughput. In addition, since the DBMS is in a separate CPU, the software and hardware can be optimized for efficiency of DBMS operations without interfering with application program resource requirements in the host CPU. Finally, the removal of DBMS functions (except for the interface module) from the host CPU greatly reduces the host CPU resources now diverted to DBMS processing and makes those resources available for application program throughput.

In FY78 the Back-End DBMS (BE-DBMS) software was delivered by the contractor and installed on the Center's demonstration system. The system was available and preliminary testing began in the Summer of 1978. In addition, an arrangement was negotiated with the Naval Regional Data Automation Command (NARDAC) (Washington) for a joint evaluation of the BE-DBMS. Under this agreement the BE-DBMS was connected to NARDAC-Washington's IBM-360 as well as to the Center's CDC-6000 computers. Also, while preliminary test and validation of the system was underway, the Center and NARDAC developed a full scale test plan to be executed in FY79.

In FY79 all aspects of the BE-DBMS will be thoroughly tested using the two host computers as laid out in the test plan. This testing should identify the strong and weak characteristics of the BE-DBMS.

The Remote Control Access task, begun in FY77, will identify electronic methods (signature pen, fingerprint, handprint, voice recognition) which can be used to validate the identity of a remote terminal user and to overcome the uncertainties of conventional password systems. It will also develop test procedures for evaluating electronic identification devices in a terminal environment. Such an electronic identification system integrates one of these devices with the remote terminal and provides for a

physiological identification of the user, giving the internal computer security software an exceptionally high degree of confidence when determining the access rights of the user. Unauthorized access via terminals becomes much more difficult if not impossible.

In FY78 a test pen device, which was developed by SRI, was interfaced to a TTY-compatible terminal. A microprocessor-based interface was designed and constructed for this purpose; control software for the microprocessor was developed. The ball-point signature pen (see Figures 29 and 30) has an instrumented point which measures the forces exerted in writing. The measurements can be stored and used later to certify an individual's identity by comparing a new writing specimen with a previously stored profile.

In FY79 the pen-terminal feasibility demonstration device will be tested and evaluated to determine the pen's ability to provide a practical level of identification and to eliminate (or reduce to an acceptable level) the possibility of forgery. In addition survivability of the pen in a terminal environment will be evaluated. Results of this testing will be documented and if the tests are successful, guidelines will be provided for procuring and using the device for secure terminal control.

Automated Graphic Sciences (AGS) Program

The Automated Graphic Sciences (AGS) program, sponsored by the Naval Supply Systems Command, was undertaken in November 1976 to provide NAVSUP and other Navy commands with RDT&E support in automated methods of managing, disseminating, and using graphic information. The technologies involved include, among others, micrographics, word and text processing, interactive graphics automated storage and retrieval methods, and electronic distribution of information. A major goal of the project will be to combine these technologies in the development of a publication system which can accept graphic data in a variety of forms and media; automatically store, retrieve, and edit the data; and provide output suitable for photocomposition equipment or for electronic storage and communication devices.

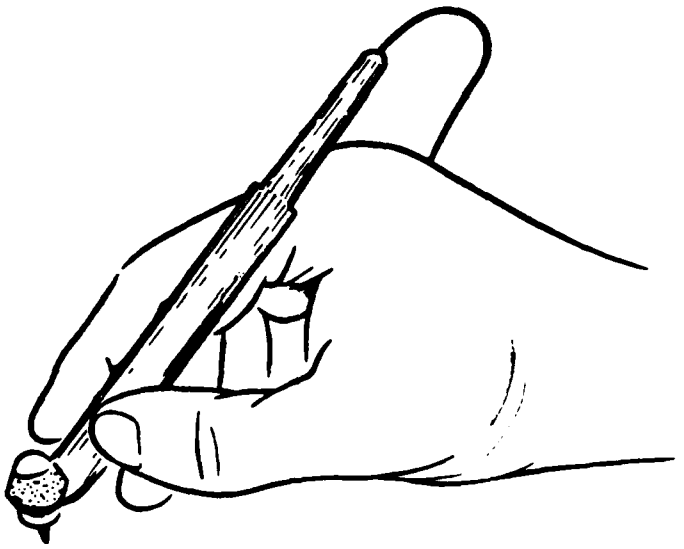


Figure 29 - Signature Pen

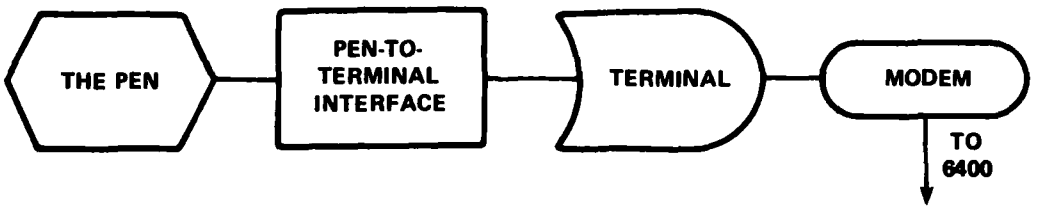


Figure 30 - Signature Pen Environment

During FY78 three major lines of investigation were pursued. A preliminary plan for developing an automated publishing capability for the Navy was developed and has been forwarded for review by the Navy's publishing management. A technical and economic study is being conducted at the Navy Publications and Forms Center (NPFC) to determine whether their current practice of warehousing large quantities of paper documents can be replaced by an automated microfilm storage, retrieval, and demand printing system. Such a system would not only significantly reduce paper volume (printing, storage, distribution) but would also significantly reduce costs.

A study was begun to determine the technical and economic feasibility of introducing aperture card, automated storage and retrieval technology to the Ships Parts Control Center (SPCC). SPCC maintains a multi-million card file of engineering drawings for reference use by both internal and external personnel. Currently, this operation is primarily manual and is difficult to control and manage effectively. Automation could significantly increase the ability to access the data and to control it efficiently.

A third effort was the initiation of studies into automation of office functions (for professionals as well as clericals) and communications. These concepts would revolutionize the way individuals conduct their daily work and communicate within an office as well as with the external world.

In FY79 demonstration models will be developed as follow-ons to the NPFC and SPCC studies. Additionally, an automated office environment test bed will be planned and initial steps taken to develop such a facility.

Source Data Automation (SDA)

Within the Naval Supply System data are generated by widely divergent sources and subsequently transmitted to many different data processing sites. The data errors and time delays in this data entry chain are considerable and data bases often have significant error levels and may be as much as six months out of date. In a system as large as the supply system, in which the inventory control points alone process one million transactions per month, data purity control is a tremendous problem. A

solution to this problem is to automate collection of data at its source. At that level personnel have the knowledge to quickly and accurately correct errors and the most significant source of time delay is virtually eliminated.

This project has two objectives: (1) to investigate new technology in source data automation (SDA), and (2) to conduct tests of SDA devices and methods within actual NAVSUP data collection environments and to recommend technology for the solution of specific problems. In FY78 planning was begun on both aspects.

In addition, DTNSRDC was requested by NAVSUP to develop a solution under the Source Data Automation program to a serious material inventory control problem aboard the CV's. The ships' outdated automated inventory control system (SUADPS) was affecting the ability of CV's to keep equipment and systems in an operational status. Manual transcription and keypunching of data, with error rates as high as 40 percent, and the long SUADPS processing cycle result in repair parts and supplies taking several weeks to appear in inventory records; other items are stored in locations which do not agree with the records. Under these conditions it has been estimated that as much as $100K worth of materials cannot be located each day. Shipboard system repairs are delayed and unnecessary expenditures of scarce funds to reorder materials may occur.

Two constraints were placed on the solution to this problem: (1) because SUADPS is outdated and soon to be replaced, no revisions could be made to that system; and (2) because of the lead time needed to revise shore-established procedures, the solution must not affect shore procedures.

The solution under development by CMLD is a front-end (to SUADPS) system based on the intelligent terminal technology previously demonstrated in the NAVSUP sponsored Data Entry Aboard Ship (DEAS) project. This front-end system will permit the interactive recording of material receipt data. One of the two manual transcriptions will be total eliminated. For the remaining transcription only the requisition control number

will be entered to display the original requisition data stored in the Receipt Processing System (RPS) files. Supply personnel will need to enter further data only if the information on the receipt document differs from the original requisition. RPS will validate all the material receipt data (interactively) prior to submisison to the SUADPS programs. Furthermore, supply personnel will be able to interactively query RPS to determine requisition status or the location of received materials. Figure 31 shows the hardware configuration for which RPS is being developed and which will be installed on USS DWIGHT D. EISENHOWER in FY79.

In FY79, the SDA study will be completed and a long-range research plan will be developed for the program.

Printing Resources Management Information System (PRMIS)

CMLD continues to provide technical support and guidance to the Navy Publication and Printing Service (NPPS) headquarters in developing a major computer-based management information system. PRMIS will be used to collect management data from NPPS field activities into a centralized data base with capabilities for interactive access and production of management reports. PRMIS will consist of eleven functional subsystems supporting applications such as cost and financial accounting, equipment configuration, inventory control, and personnel administration.

In FY78, the Department helped to develop and test prototype capabilities for the Reprographic Subsystem in PRMIS. A test data base was defined on the Center's CDC 6700 computer along with on-line and off-line procedures for updating and maintaining this file. On-line procedures were developed using the System 2000 Data Base Management System, and data entry frames were designed for collecting data off-line onto floppy disks on the Linolex Intelligent Terminal for later transfer to the central data base. These frames simplify data entry for the user and allow screening of data for errors and completeness prior to updating the main file. Management reports summarizing data base information were also developed. After satisfactory tests were completed, the prototype system was converted to the IBM-370 computer at Martin-Marietta Co., Orlando, Florida, and transferred to a contractor for integration into PRMIS.

Figure 31 - Rack Mounted Inforex 7000

In FY78, work also began on developing a similar prototype system for inventory management of Navy Word Processing Equipment (WPE) in PRMIS. Data base design began, file maintenance procedures were outlined, and major reports were identified. This work will be completed in FY79.

During FY79, research is also planned to develop models for equipment selection and lease-vs-purchase analysis of Reprographic and Word Processing equipment. Such models would assist Navy asset managers in determining procurement strategies and in matching user requirements with performance and cost factors in selecting equipment. These models, when integrated into PRMIS, are expected to provide tools for improved life-cycle management of major pieces of Navy office equipment.

Distributed Terminal Processing

Within the Naval Supply System the processing load on current computer systems is rapidly approaching saturation and planning is well underway for replacement systems. However, the existing huge backlog of system development requests and the necessity to implement a totally interactive/on-line environment portends that the demands for service from these new, more powerful, future systems will continue to grow, quite likely at an increasing rate. Experiences in the transition from second to third generation computers have demonstrated repeatedly that demand for service expands to the capabilities available. Therefore, since we can expect ever increasing demands on the new, planned systems, it is reasonable to begin, now, planning the evolutionary expansion of those systems to avoid the saturation stalemate which threatens current Supply computer systems.

The concept which this research project will investigate (as a means to that evolutionary development) is distributed processing. Under this concept, actual analytical processing of supply data would occur at a localized processor in an interactive model under the control of a supply analyst. The central CPU would assume the roles of (1) a data computer (executing all the data management functions), and (2) a large-scale processor for executing tasks which cannot feasibly be distributed to

smaller processing units. The advantage of such a concept is that a very large information system (such as the Inventory Control Points) can grow to meet expanding service demands without a monumental growth in the central CPU. This concept also permits an eventual, less traumatic replacement of the central CPU as it reaches the limits of its capacity. Since user applications are isolated from the central CPU, standard interfaces and communications protocol could make that transition almost transparent.

The purpose of this research and development project is to explore ways in which distributed processing concepts could be implemented in the Navy Supply Systems to achieve the desired objectives. The project seeks to identify three major elements needed to make the concept viable: (1) the types and scope of applications amenable to distributed processing, (2) the hardware/software capabilities needed to support such a capability, and (3) conceptual guidelines for implementing the concept.

In FY78 the technology required for the envisioned local processor was studied and a specification for a demonstration model was developed. A study of the Supply processing environment was undertaken to determine the types of applications which may be amenable to distributed processing and the levels of distributed processing that are practical, given the different applications and their operating characteristics.

In FY79, following completion of the application study, a demonstration system consisting of hardware and a selected application will be designed and software development will be initiated. It is intended that this system will be installed in the Inventory Control Points for test and evaluation

Shipboard Mass Storage

Over the past year, we have been investigating various hardware information processing devices for use in shipboard and laboratory environments. Whether or not secondary storage devices like the CCD device mentioned previously will come down sufficiently in cost to replace disk storage is not clear, but in the meantime, shipboard disk storage is of current interest to the Navy. As a result, we have sought out fixed head disks for environmental testing both in a testing laboratory and aboard ships. Two disks were selected, laboratory tested and evaluated, and documented.

The tests included temperature/relative humidity, vibration, shock, inclination, electromagnetic compatibility, power, altitude, package drop, and vibration specifications derived from the Telecommunications Equipment Low Cost Acquisition Method (TELCAM) and the Data Entry Aboard Ship (DEAS) studies. Since the end use of the disk will be in a logistics support operation, new commercially ruggedized specifications--not necessarily up to MILSPEC standards--are expected to emerge from these tests and the resultant documentation. One disk has been selected to be shipboard evaluated in FY79 under the auspices of NPRDC. A picture of a typical test set-up is shown in Figure 32. In addition, a contract is being considered to investigate the feasibility of considerably improving the performance of the selected disk by a new proprietary read/write head design.

Microprocessor Interfaces

Another hardware device class under study is that of microprocessor technology. During the past year, we have been engaged in three projects involving microprocessor applications. The Content Addressable Memory/-Charge Coupled Device (CAM/CCD) associative memory, more fully described on page 63, requires a microcomputer as its controller, the design of which was firmed up in the past year. Secondly, we designed, built, and tested a microcomputer system for acquiring handwritten signature data for transmission via an RS232 interface to a modem for the purpose of verifying the identity of remote users of a central computer. The system consists of a XEBEC pen interface, an A/D converter and interconnection board, and a Texas Instruments TMS9900 based microcomputer, a picture of which is shown in Figure 33. Thirdly, a study was initiated into the cost effectiveness of converting large ship structures software into networks of microcomputers.

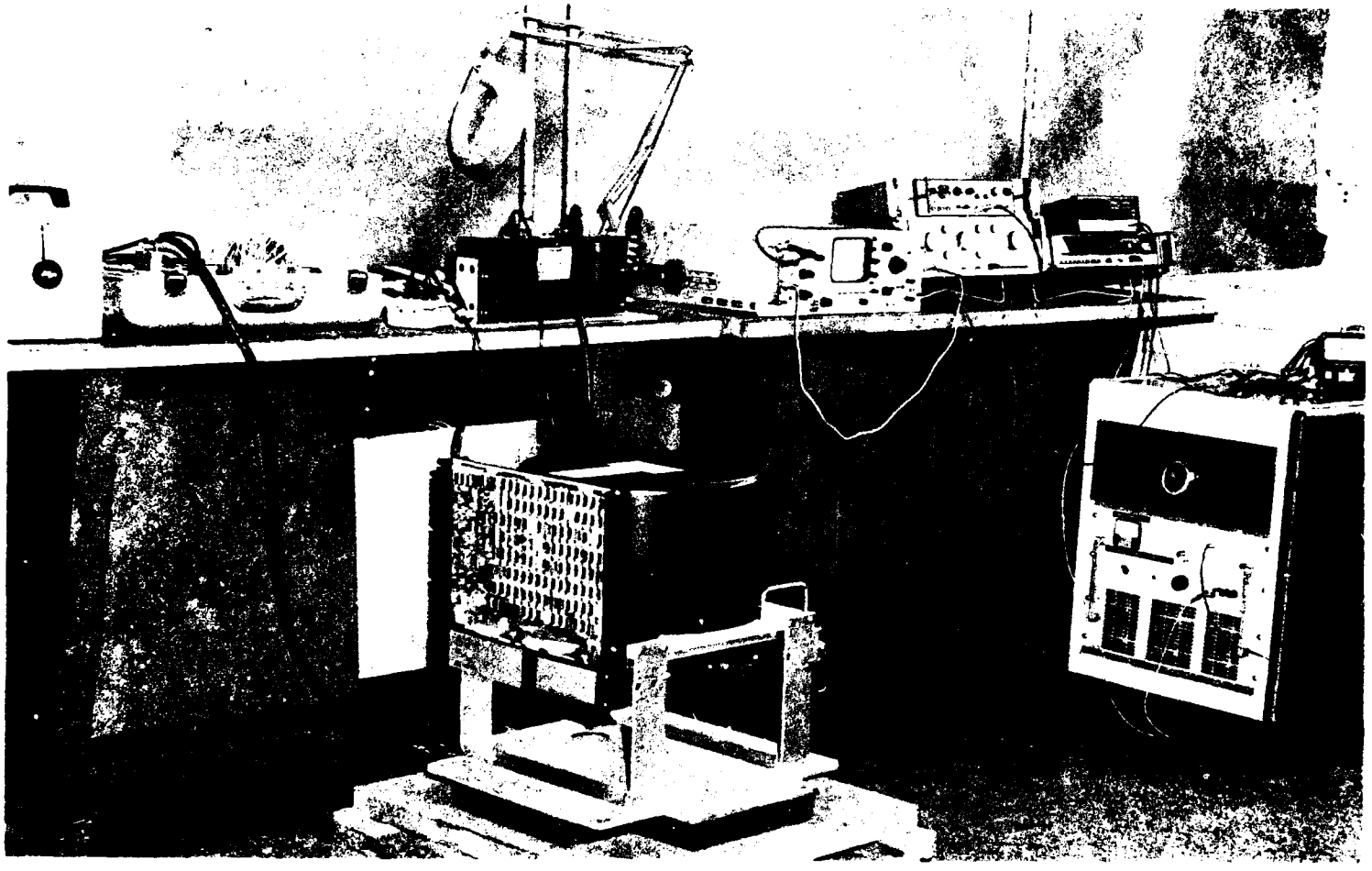


Figure 32 - Safety, Ground, Leakage Current, and
Electrical Power Test Setup

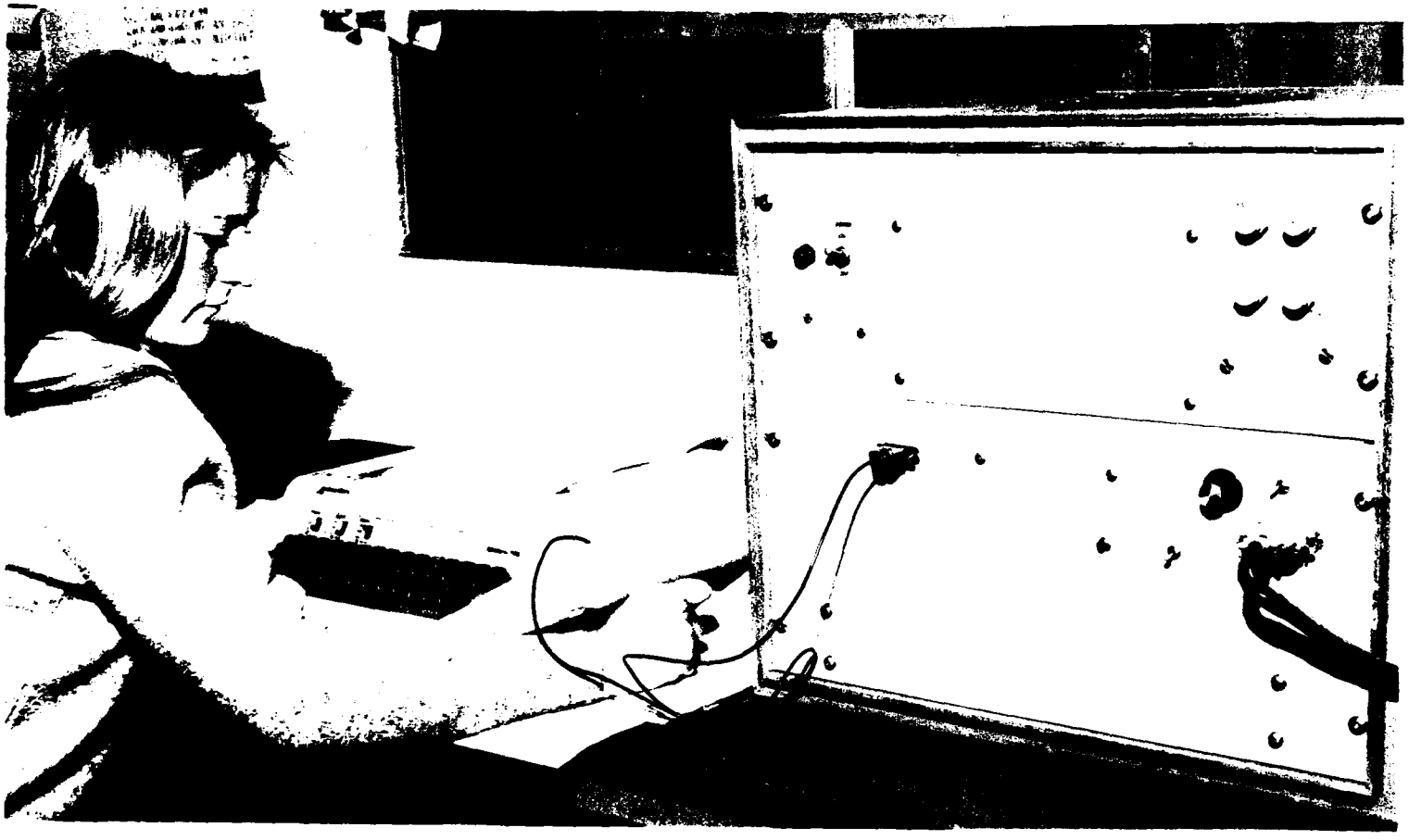


Figure 33 - Microcomputer Interface for Signature Verification System

PATTERN RECOGNITION

Acoustic Transients

The FY78 CMLD pattern recognition effort, in cooperation with the Ship Acoustics Department, continued its application of previously developed pattern recognition techniques to certain underwater acoustic transient signals (generated by such shipboard activities as hatch closings) for the ultimate purpose of improving ship silencing. Contact with Navy and other DoD laboratories involved in signal processing investigations has revealed that transient analysis has become an area of increasing interest, due partly to the success of the Navy's ship silencing efforts, especially for steady-state signals. Fundamental to our approach is the adaptation of waveform parsing, statistical classification, and contextual analysis techniques to these acoustic signals. The syntactic techniques being used at CMLD do not seem to be in common use elsewhere. Two major problems encountered in our research are the paucity of data and the noisy environment in which signal data are collected. In an effort to overcome these difficulties, we are securing access to available data bases, investigating the possibilities of simulation and/or increased data collection, and contriving new noise filtering procedures. The latter effort is focusing on tracking and smoothing procedures.

To implement the analysis procedure so that a signal analyst can interact with the data in a convenient and meaningful way, a user-oriented signal analysis system has been developed by interfacing minicomputers, peripheral devices, and their controllers. The user can now manipulate and analyze digitized data as if it were stored in a virtual memory, without regard for its actual location in core, on disk, or on magnetic tape. With the help of the graphics screen, the user is now able to view the signal as an uninterrupted sequence of samples in the original time domain or in a transform domain. He can move along the signal stream, partition, modify resolution, transform, track, smooth, extract syntactic features and measurements, parse, and test discriminant hypotheses.

FY78's effort resulted in the creation or modification of several significant signal processing and pattern recognition software routines. For example, bandwidth information and graphics parameter interactions were added to PEAKPIC, a routine for selecting relative intensity peaks in a time slice of the short-term power spectrum. The routine SELECT was written to interactively select out portions of the spectrum time axis to be tracked and interfaced to the tracking, smoothing, and parameter measuring routines TRAKR, KLASIT, and WAMSR, respectively. TRAKR is a computer procedure for identifying relatively high intensity tracks in a short-term power spectral decomposition of a signal against a background of ambient noise. The program must contend with unrealiable data regions and with emerging, joining, splitting, and disappearing tracks. The algorithm employed bears similarity both to format tracking encountered in speech processing and to line detection found in picture processing. TRAKR output may be fed to KLASIT, an interactive graphics exploratory data smoothing and segmentation routine that utilizes both local and global properties of the data at hand to make smoothing decisions. KLASIT output may then be fed to WAMSR which extracts both syntactic and physical features of the signal. These routines were interfaced over the past year with the waveform recognition training and testing routines WAVAN and TESWAV, respectively. WAVAN and TESWAV were written this year in the GIRS/GIRL data graph manipulation system to store and recognize syntactic waveforms by means of their primitive transition shapes and by means of certain physical parameters like intensity, duration, and decay time. A MERGE routine was written to handle tracks of indeterminate temporal and spectral range. The feat of combining track segments was accomplished by storing the plex of emerging, joining, splitting, and disappearing track strings in a GIRS graph with considerable economy of storage and flexibility of access. The new structure, however, necessitated some modification to the original tracking routines. A MOVIE routine was written to effectively scroll the tracks down the screen (see Figure 34) at variable rates of movement as a visual aid to the analyst. We have begun looking at some real

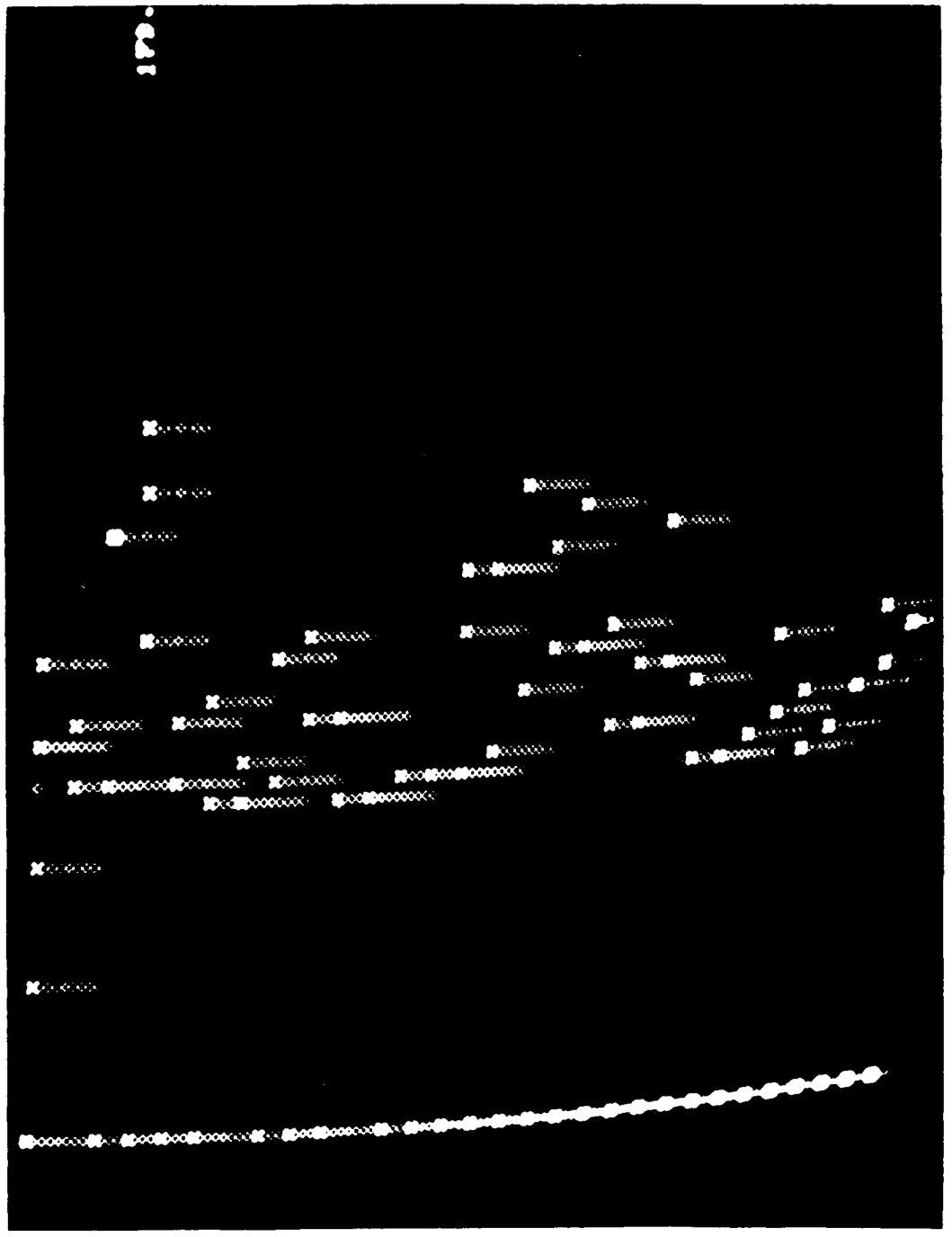


Figure 34 - Graphics Track Scrolling

data with these signal analytical tools and have artificially generated more data by writing routines to add noise to the transient samples at hand. However, we are investigating a more satisfying means of experimentally and inexpensively generating transient data that are similar to the data of interest.

As part of the transient signal classification effort, it is necessary to manipulate syntactic information in graph-oriented structures. The GIRS systems for handling such structures both in-core and for graphs extending to disk storage have been documented. The out-core version has the capability of storing graphs on pages of arbitrary length in uniform storage increments called continuants (see Figure 35). Each continuant of a

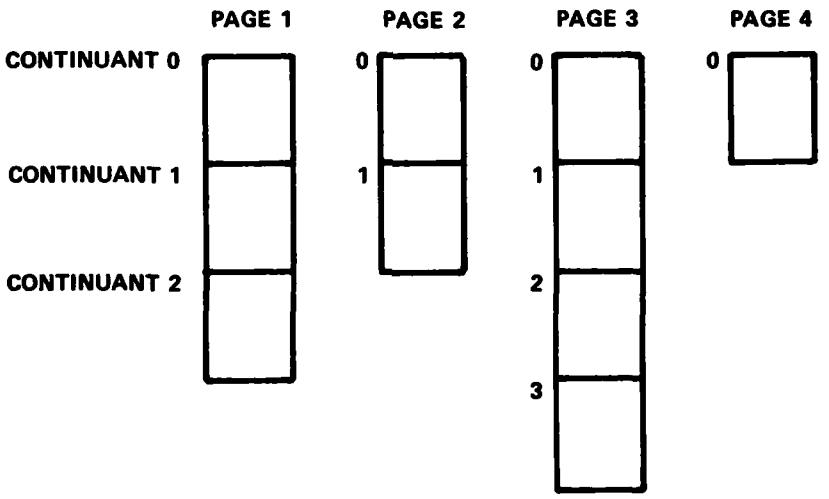


Figure 35 - Variable Length OUT-CORE GIRS Pages

given page has the same address image as any other continuant of the same page and the internal storage mapping is that of in-core GIRS (see Figure 36). In addition, an analysis has been made of the PDP 11/45 extended memory system by use of the Memory Management Unit and routines have been written to allow GIRS the full use of the 128K words of core that are available. The documented analysis concluded that the extended memory concept effectively provided a fast but awkward overlay mechanism to the FORTRAN user. On a software level, the graph interfaces with a data description language developed at DTNSRDC called GIRL/FORTRAN. On a hardware level, however, the processing can be quite cumbersome, and last year's project in the implementation of associative memory systems has been continued by furthering the construction of a small paged Content Addressable Memory/Charge Coupled Device (CAM/CCD) memory system for use with the PDP 11/45. The major design issue settled in the past year was to choose a method of detecting and identifying multiple responses to an associative query. The analysis performed thus far has established the efficacy of a modified counting response resolver (see Figure 37) and a methodology for optimizing the design of an associative memory for a given suite of software. A sample estimate of implementation cost versus average retrieval time is shown in Figure 38. This CAM is still to be driven by GIRL/FORTRAN but without the software GIRS infrastructure. One means of speeding up the inevitable paging process has been to interface the CAM with a CCD which offers 65K 64-bit words of secondary storage with retrieval times an order of magnitude greater than that of fixed-head disk at about an order of magnitude greater cost per bit. Figure 39 shows the CAM/CCD interface. The system is about 60 percent complete.

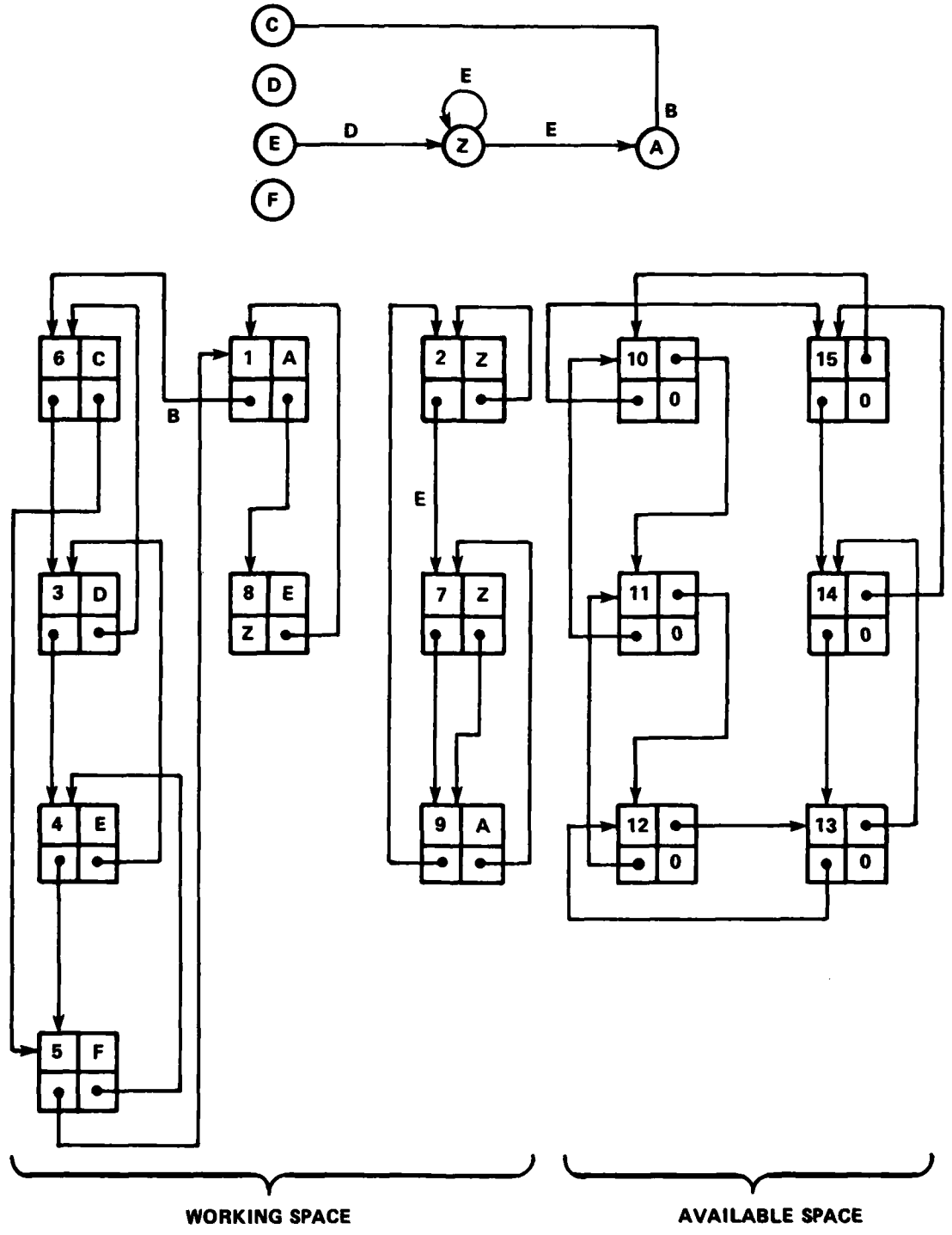


Figure 36 - Example of Graph Structure and Associated Internal GIRS Pointer Graph

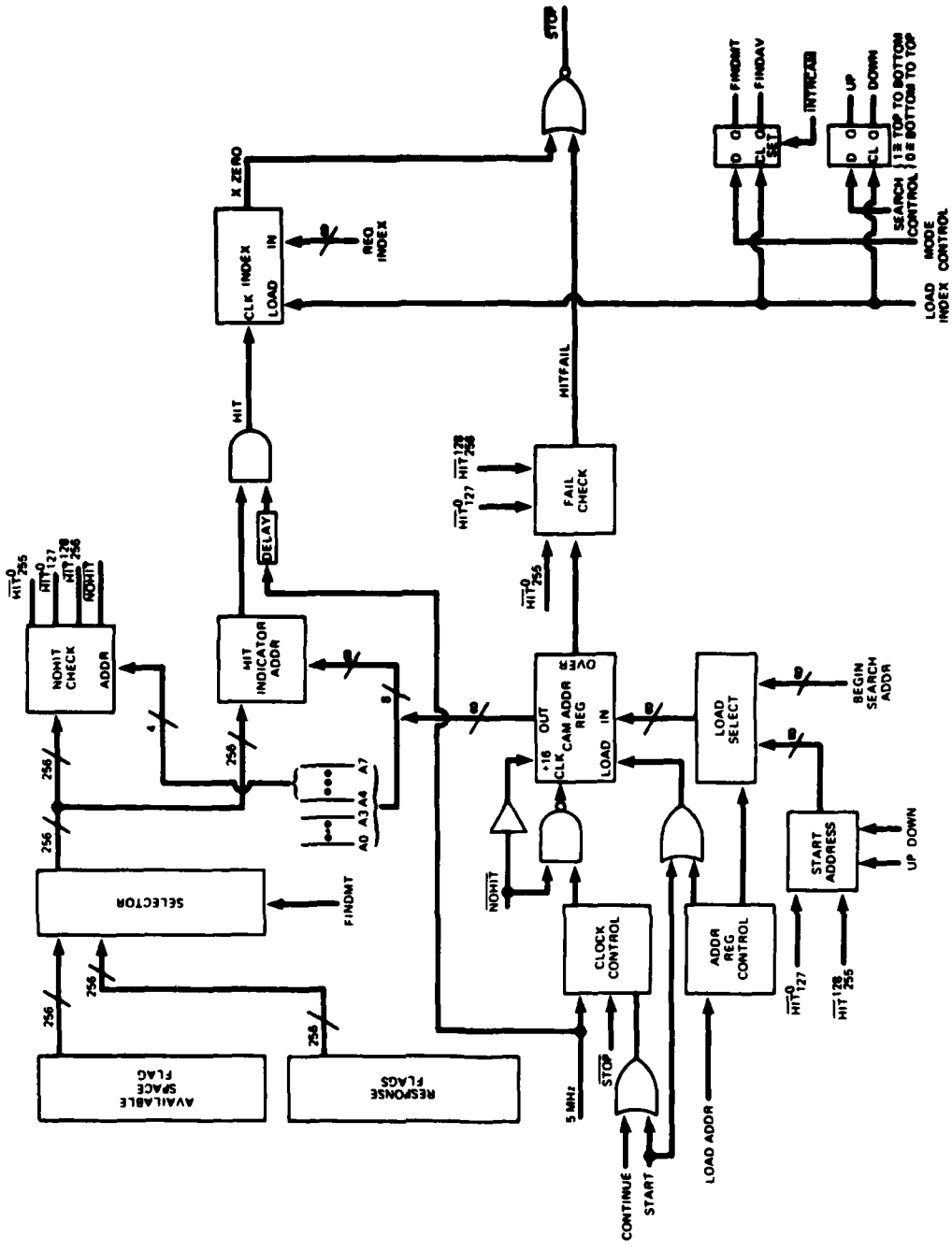


Figure 37 - Counting Response Resolver

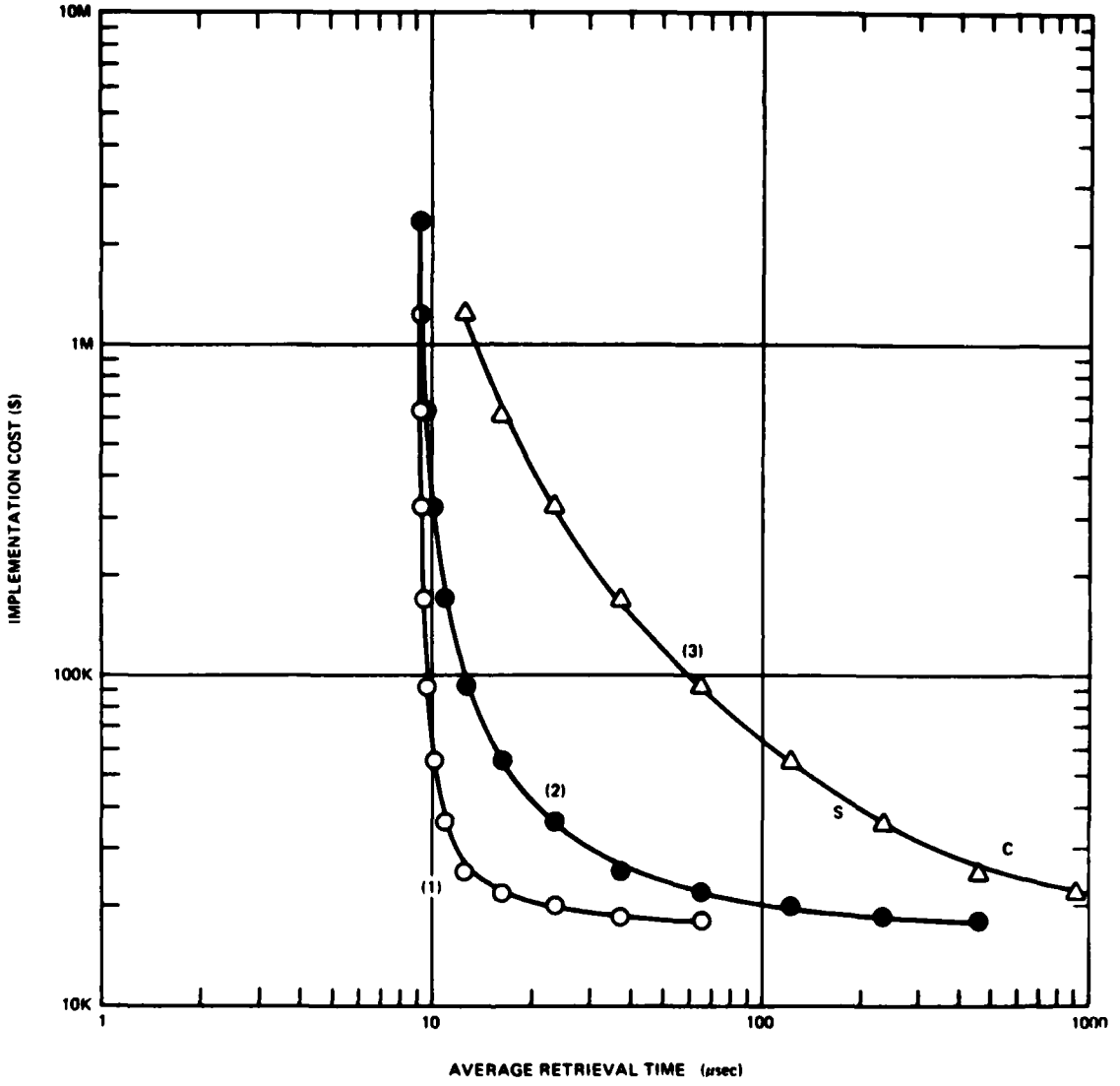


Figure 38 - Cost Performance Relationship

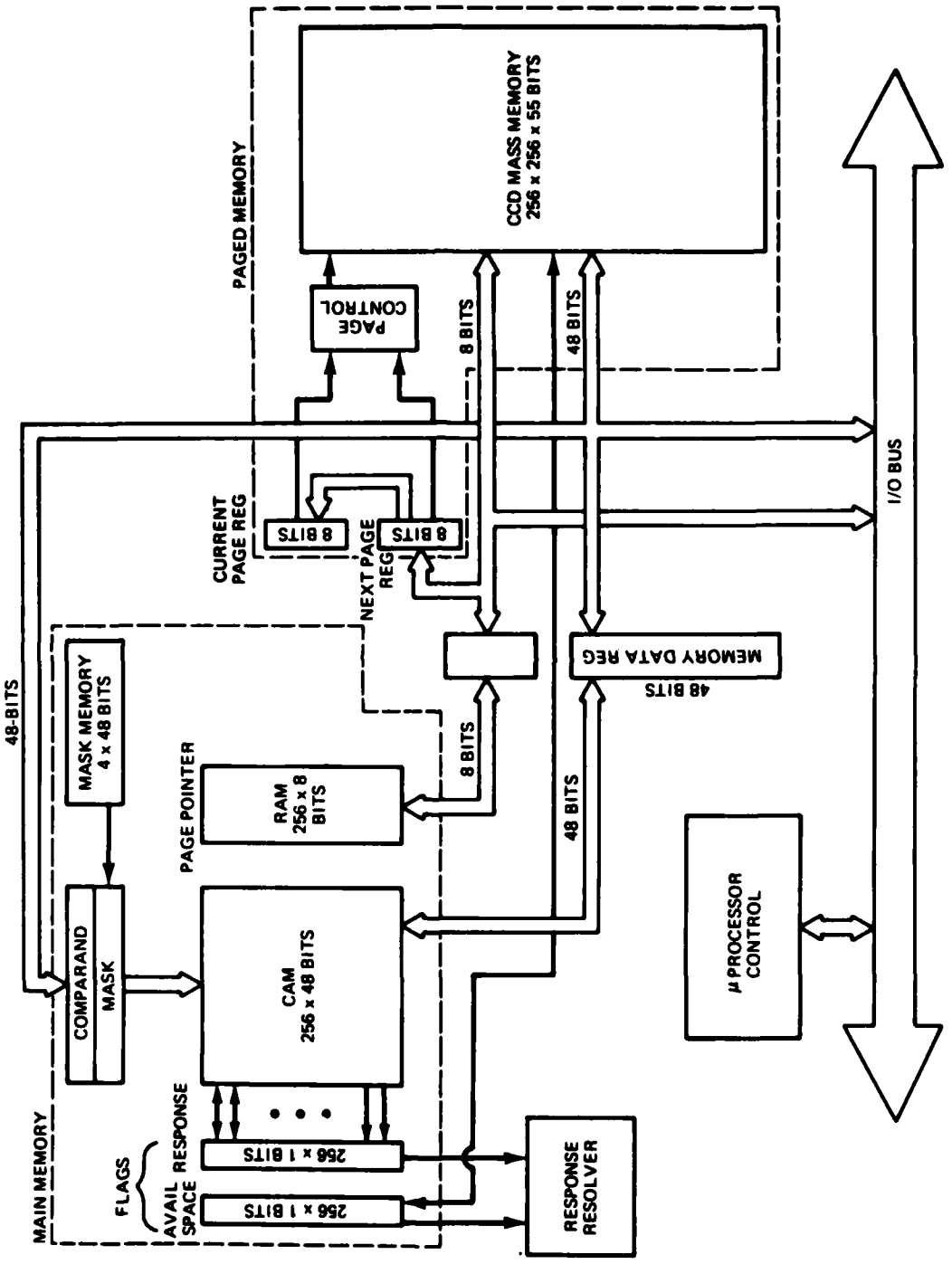


Figure 39 - Associative Memory System

One side benefit of the work in associative processing will be its use in information retrieval systems. As an example, a report information retrieval system has been developed on the PDP 11/45 employing GIRS, a simulated associative (content-addressable) memory. The system features an easily extensible, transformable, relational graph separated from the actual data base. One can currently interrogate, delete, and augment a 2500-record data base for logical combination of data items in an interactive mode. This system demonstrates some of the basic elements of a GIRL/GIRS DBMS described in a feasibility study performed previously of an interface to an integrated computer aided ship design environment. The example report information retrieval system was documented in the past year.

Engineering Line Drawings

Capturing data in digital form from engineering drawings and blueprints is a time-consuming manual task that computer-aided ship designers currently face. When computerized design data bases come into common usage and the initial archival translation has been completed, the problems of acquiring hand-drawings and of translating data from one system to another may still require a less tedious solution than now exists. Therefore, the resolution of optical digitizing devices is being studied and an on-line experimental system has been developed for acquiring line data by the PDP 11/45. During the past year, this system, called the Graphics Line Scan System, has been documented. A 4' x 8' drill table has been acquired and modified to allow x-y travel for the vidicon (see Figure 40) and plans are underway to motorize the table slide bearings under computer control. The tracking and merging software routines mentioned previously for use with acoustic data have been modified to serve as an initial step in reducing the video raster data to graphics vector form. On the basis of our background in handprinting recognition and syntactic parsing, the data reduction/description problem is being analyzed with a view to producing an economical, efficient, automatic means of acquiring and processing hand-drawn data. The final step in reduction is content-oriented, and we are looking into several subject areas for suitable classes of drawings to be analyzed.

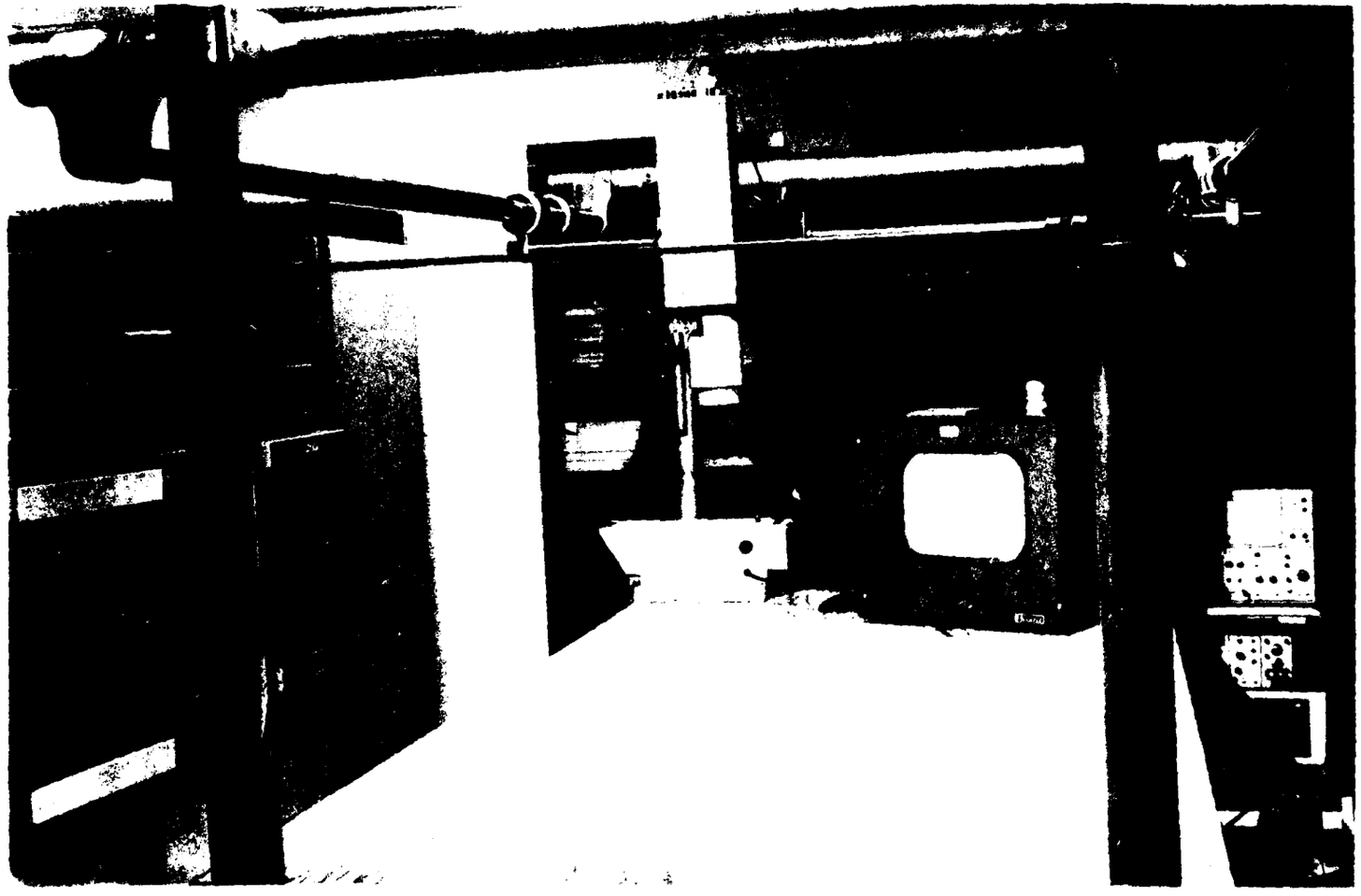


Figure 40 - Graphics Line Scan System

Surface Effect Ship Broaching

Finally, progress has been made in analyzing surface effect ship broaching data by means of the On-Line Pattern Analysis and Recognition System (OLPARS), acquired from Rome Air Dvelopment Center. OLPARS is an interactive graphics means of visualizing and manipulating projections of a high dimensioned measurement sample space. Detection of broaching is critical in operating a surface effect ship in order to avoid pump underload and the subsequent re-load shock. Thus far, we have achieved high broaching recognition rates at an acceptable false-alarm frequency for 20-dimensional measurement data. Analysis will be extended to further data, and parameter sensitivity will be investigated. The results of the initial experiments have been completed and documented. The Surface Effect Ships Project Office (PMS 304) is considering the possibility of implementing the algorithms in a hardware controller to reduce the effects of broaching.

ADP SUPPORT TECHNOLOGY

SHARP Data Base Management System (DBMS)

SHARP is a self contained COBOL DBMS designed to allow nontechnical users to define, build, maintain, and interrogate data bases while minimizing the need for application program interfaces. It allows on line and off line access to data bases through the use of English like language for specifying data base structures, queries, computations, and report generation. These languages are well suited for interactive use from remote terminals. The SHARP DBMS is outlined in Figure 41.

At the end of FY78, 50 data bases were operational under SHARP at DTNSRDC on the CDC 6000 Computer System for a variety of applications including Navy Logistics, Library Science, Ocean Science, Contract Management, Personnel, and Accounting.

SHARP users and their applications include:

NAVSEA PMS 383 - (Logistics) Monitor ship acquisition data such as GFM

NAVSEA PMS 303 - (Logistics) Provide failure analysis for Navy hydrofoils

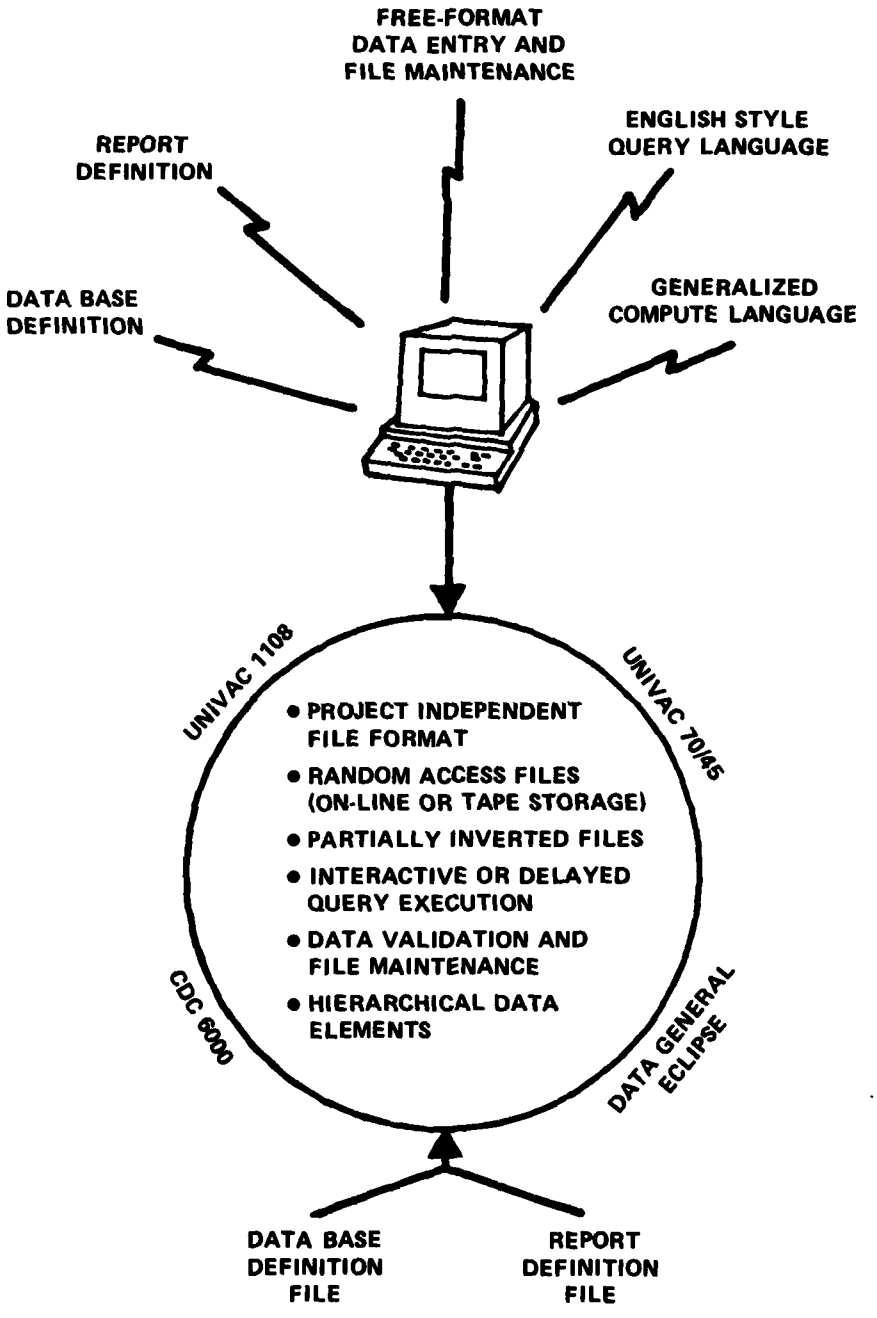


Figure 41 - SHARP Data Management System

DTNSRDC (Code 11) - (Accounting) Monitor contract information; (Library Science) Track technical documents on advanced ship design

Univ. of Virginia at Charlottesville - (Ocean Science) Monitor research projects for the Office of Naval Research

NAVSEA Technical Library - (Library Science) Store and retrieve technical documents

NAVAIR Systems Command - (Logistics) Analyze aircraft failures; (Accounting) Analyze budgets

NAVSUP (Code 052) - (Logistics) Containerized Cargo Shipping Analysis

It is anticipated that, in FY79, additional personnel from NAVSEA and NAVSUP will become SHARP users.

DTNSRDC Management Information System (MIS)

Responsibility for the development and operation of the Center MIS was assigned to the Financial Management Department beginning in FY79. CMLD has therefore transferred all programs and documents for these systems to the personnel now responsible for them. However, throughout FY78, the Department continued to support MIS development not directly related to Financial Mangement, Supply, or Personnel. This included work on the Industrial and Facility System, the Instrument Inventory System, and the DTNSRDC Library System.

During FY78, CMLD was requested by the Industrial and Facilities Directorate to analyze, design, and develop upgrades to their Work Status Reporting System. A prototype system, based on changes and additions to the existing system, was developed and tested. Recommendations were made for an advanced interactive version of this system, to become part of a future comprehensive scheduling and reporting capability. Improvement of this system is now the responsibility of the Financial Management Department.

Improvements and changes were also made during FY78 to the Center's Instrument Inventory System and the Library System that simplified maintenance, improved user satisfaction, and reduced processing costs. Programs, files, and documentation for these systems were transferred at the end of FY78 to the Financial Management Department.

COMPUTER NETWORKING

The Navy Laboratory Computer Network (NALCON) is a research and development effort to determine the impact of computer networking on the economy, effectiveness, and enhanced capability of computer support to the Navy laboratories. By interconnecting the major general purpose computer facilities of the Navy laboratories, NALCON will provide interactive processing, remote job entry, file transfer, and where applicable process-to-process communication capabilities. Network communications will use the ARPANET, an operational packet Switched Communication Network of the Defense Communications Agency.

Interface to ARPANET is provided by minicomputer front-end processors which insulate the individual network computers from the network architecture. Implementation of this physical aspect of the network constitutes the first phase of the NALCON project and was accomplished during the past year. Now users at the laboratories have access to ARPANET resources and the on-line capabilities of the individual network computers are available to users located anywhere on the ARPANET. Among the services thus provided are an electronic message and mailbox service, which provides an easy and timely means by which Navy scientists can communicate with one another to pass on technical information or to make inquiries for such information; MACSYMA, a software tool for manipulating symbolic mathematical expressions; and the oN Line System (NLS) for text editing. Resources of laboratory computers are made available through NALCON Phase II software which emulates TTY terminals and allows access to host computer resources without modifying the host computer.

If NALCON is to be successful, engineering computer programs which are available on the Navy laboratory computers and which are of interlaboratory interest must be made known to the user community. The Navy Engineering Software System (NESS) effort in CMLD is addressing this problem. This effort is directed to maintaining such programs on the NALCON network; providing assistance, training, and consultation for computing capabilities; and providing new programs as required. So far, 27 programs have been identified in which four or more laboratories are interested.

NALCON Phase III covers the development and implementation of a general host front-end protocol that allows common software to be used for the different host computers. The Naval Weapons Center has completed the NALCON host front end Phase III implementation.

NALCON Phase IV adds a File Transfer Protocol to the system which can be used for transferring ASC22 files and serves as the basis for Remote Job Entry. Protocols for the Host Front End implementation of F7P and RJE were developed by Computer Science Corporation.

The NALCON Information Exchange Center (IEC) went into full operation in fiscal year 1978. A software reference data base containing more than 1800 entries is available. The IEC manager has been receiving (by phone and mail) and processing queries for NALCON users.

In FY79, laboratory coordinators will be trained to initiate queries, via terminal, from their own sites. Also, a coordinated effort will be made to promote use of the facility and to generate a continuous flow of submissions.

COMPUTER AIDED DESIGN AND MANUFACTURING

The Department's work in computer aided design and manufacturing is concerned with the development and implementation of computer based systems needed to improve the quality of ship design and construction, and to reduce lead time and cost in the ship design and construction process. A major program under this effort is the Computer Aided Ship Design and Construction (CASDAC) project. Over the past several years, our emphasis in this program has been on developing the necessary software technology and demonstrating feasibility of integrated design systems for use in preliminary and contract design. While this work will continue, our present program is in transition from emphasis on preliminary and contract design, where the main user is the Navy, to developing computer based systems and tools for use in ship detail design and construction, where the main user of our products will be the Marine industry. The detail design

system includes the following subsystems; hull, piping, electrical/-electronics, machinery/handling, and heating, ventilating, and air conditioning. Progress on this project was impeded during FY78 by temporary but severe funding reductions. However, a major milestone was the development, in collaboration with a number of Navy activities, of a Navy Decision Coordinating Paper which was approved by OPNAV in April 1978, resulting in the formal establishment of the CASDAC program. Funding in the amount of $60M (FY77 dollars) over eight years has been proposed and is expected to become available beginning with the FY81 budget.

HULL DESIGN AND CONSTRUCTION SYSTEM (HULDAC)

A HULDAC engineering analysis is being performed to identify the scope of HULDAC, to describe the current hull detail design process, and to describe the proposed process which will result from HULDAC development. To document this analysis, two drafts of the HULDAC Functional Description have been written; a third draft and a HULDAC engineering analysis are currently being completed. This analysis has drawn extensively from two previous, extensive descriptions of the ship design process ((1) Gibbs & Cox, (2) IITRI), from a shipyard survey, and from the HULDAC industry consultants. The HULDAC Functional Description and HULDAC engineering analysis are being correlated with overlapping CASDAC descriptions stemming from a CASDAC Level IV/V Top-Down Study and a study of CASDAC data management requirements.

HULDAC contracts were let to procure the services of three consultants in current U.S. ship steel design procedures. These consultants critiqued the HULDAC engineering analysis, provided information and insights on current hull design methods and on desirable future computer design methods, and provided documentation and detailed instruction on the two principal numerical control (N/C) systems used in the U.S. for ship steel fabrication, AUTOKON and SPADES.

A principal goal of HULDAC is to streamline the transfer of digital information from the Naval Ship Engineering Center's (NAVSEC's) Levels I-III CASDAC design into HULDAC software systems used in the shipyards. The development of a functional description for the HULDAC Level III/IV Interface has begun and informal discussions have been held with some NAVSEC personnel involved with CASDAC Level III development. Funding limitations have not permitted sufficient interaction with CASDAC Level III to ensure an acceptable interface.

COMPUTER-AIDED PIPING DESIGN AND CONSTRUCTION (CAPDAC)

Computer-Aided Piping Design and Construction (CAPDAC) addresses detailed piping design, which accounts for some 25% of ship detail design costs.

During FY78, personnel at Mare Island and Puget Sound Naval Shipyards were trained and assisted in the use of some sophisticated pipe arrangement drawing and detailing computer programs via remote job entry (RJE) terminals. These programs build a three-dimensional model of piping data. Computer programs can access these data and output piping arrangement drawings and sketches for the fabrication of pipe sections. The fabrication sketches are readily understood by relatively unskilled labor and substantial economies are effected in pipe fabrication. The programs contain many error-checking modules that enhance the accuracy of the process and the fabricated pipe sections. These programs were obtained from the Electric Boat Company by CMLD and have been made available to shipyards (via RJE terminals) on the UNIVAC computer at the National Bureau of Standards.

These programs were initiated into production use at the Puget Sound Naval Shipyard for modifications to USS ENTERPRISE. Ingalls personnel were trained in their use at the David W. Taylor Naval Ship Research and Development Center.

A document was developed that describes the hardware procedures and system control functions to be performed by operating personnel for the remote processing of the CAPDAC piping application programs via a Mohawk 2400 terminal emulating a UNIVAC 1004 remote batch terminal.

ELECTRICAL/ELECTRONICS SYSTEM (ELXDAC)

An electrical/electronic system (ELXDAC) engineering analysis was initiated by a contract with George G. Sharp, Inc. The current detail design, planning, and construction processes involved in the electrical/-electronic areas of Navy ship construction were documented. Conferences were held with shipyard engineers and planners to discuss and document the various methods of engineering detail design and construction. Representatives from four shipyards assisted the contractors in defining the electrical design process and in identifying the interfaces between electrical design and other ship systems. Further work is required to derive proposals for computer-aided subsystems, programs, and catalogs.

CASDAC SOFTWARE SPECIFICATIONS

A principal requirement of the detail design portion of the Computer-Aided Design and Construction (CASDAC) program is to develop and procure computer software which can be shared by the Maritime industry. Several computer programming and documentation specifications were developed by Center personnel and distributed to Naval activities in FY77. These specifications have been designed to expedite development, maintenance, and use of modular, understandable software which can be transported among dissimilar computing environments. They exploit proven software engineering techniques, and their underlying principles and basic concepts have since been accepted by Naval personnel. Comments and suggestions for improving the specifications were forwarded to Center specialists at the

start of FY78. A revised set of specifications, incorporating simplified English and other improvements, has been prepared and is awaiting final review.

CASDAC software specifications will be included within Center-managed contracts relative to developing new computer programs, documenting existing programs where no documentation exists or is judged inadequate, and converting existing programs when coding is changed and new documentation is required. Such programs and program modules will be produced generally by shipyards and will be used to assist shipyard personnel responsible for Navy detail ship design and construction.

STUDIES IN SUPPORT OF COMPUTER AIDED SHIP DESIGN AND CONSTRUCTION

Data Base Requirements

An overview of data base management systems (DBMS's) in use in the shipbuilding industry. This study reviews some commercial data bases and the potential use of current DBMS's by CASDAC, and makes recommendations for DBMS strategy for CASDAC.

Top-Down Study (Major Functions)

An ongoing study of input-output relation among major functional systems for hull; piping; machinery; electrical/electronics; heating, ventilation, and air-conditioning; and handling. It also identifies functions these systems have in common.

Environment Study

Evaluation of alternative methods of implementing CASDAC in the shipyards. Alternatives considered include the use of machine-portable code, remote job entry operation, the implementation of programs on a few major systems, networking, and the use of a turnkey hardware/software system.

Computer Science Program In Support of
Computer Aided Ship Design, Production,
Repair and Procurement

The CMLD and the University of Utah conducted a joint two-year research study to determine potential contributions and benefits to the communities involved in design, production, repair, and procurement of U.S. Navy ships from a directed research and development program in computer science. Another objective of the study was to recommend, where it can be economically justified, a research and development program that will result in products to be used in those communities.

The approach taken to meet these objectives has been

- To conduct a survey of the shipbuilding industry.
- To review the computer technology presently employed in ship design and construction and related projects in computer aided design and manufacturing.
- To project a computing environment that would substantially enhance ship design, production, and repair.
- To identify computer science areas requiring research and development if such a computing environment is to be achieved.
- To recommend an economically justifiable research and development program in the computer science areas identified.

The conclusions of the study were that there is a need for a research, development, and technology transfer program in the computer science area in support of ship design, production, repair, and procurement, and that such a program could have high payoff in making computer software development more reliable and economical, in making computer-aided design and manufacturing systems easier to use and more cost-effective, and in automating much more of the ship design and production process.

The study identified the following computer science areas as the key areas requiring additional research and development support:

- design and management of very large data bases
- computer graphics
- design automation
- production automation
- distributed computing
- software acquisition, development, and maintenance

While it is recognized that these are all active research areas in the computer science community, the study recommended that ongoing work be influenced, adapted, developed, and augmented so that it will more nearly meet the needs of the ships community.

A five-year, $7.4-million program has been recommended, including research, development, program coordination, and technology transfer. A key element in the suggested organizational structure for the program is a panel which includes representatives of the CASDAC program, the shipbuilding community, and the computer science research and development community. Such a panel would aid in identifying and prioritizing needs, evaluating proposals, and reviewing and critiquing the proposed program.

In connection with this project, DTNSRDC coordinated two workshops to which technical experts from the Navy, and other government agencies, academic institutions, and the shipbuilding industry were invited. The first workshop, held on June 29-30, 1977, reviewed the scope of the project and generated an exchange of technical information. The second workshop, held on November 21, 1978, presented the final findings and recommendations of the study.

LOGISTICS ANALYSIS

During FY78 the Logistics program became the basis for the formation of a Logistics Division within the Department. The missions and functions of the Logistics Division are to plan, manage, and conduct a research and development program in material flow technology, emphasizing logistics transportability, warehousing, logistics distribution networks, and logistics control systems. The Division serves as the Center's focal point for the Navy logistics R&D program and acts as consultant and technical advisor on logistics technology to the Chief of Naval Operations, Commandant of the Marine Corps, Chief of Naval Material, Systems Commands, Project Managers, Marine Corps Development and Education Command (MCDEC), and the operating forces. As such, its work is to adapt, develop, and evaluate new logistics technology concepts to enhance the effectiveness and reduce the cost of the Navy and Marine Corps logistics systems; to conduct assigned studies and analyses in logistics, utilizing operations research and systems analysis techniques; and to evaluate results of operational test and evaluation of fleet exercises in all areas of logistics. The Division also conducts research and development in reliability and maintainability, resource allocation, econometrics, and other methodologies needed to analyze Navy logistics problems.

As the Center of Excellence for Naval Logistics RDT&E, the Department this year has continued development of the technology base required for responsive logistics applications. The work program supports Navy and Marine Corps systems for supply, maintenance, transportation, and acquisition and for management control of these functions. It includes overall Navy Logistics R&D planning and development of the Navy's Technical Strategy for Logistics. The Logistics Analysis projects are grouped in the areas of Macro-Analysis and Forecasting (logistics planning, management, and operations); Sealift, Basing, and Underway Replenishment (use of auxiliary and merchant shipping and development of new concepts for at-sea delivery); Logistics Supply Systems; Materials and Special Handling (preservation, packing, and packaging); Maintenance and Repair; Acquisition and Support; and Physical and Information Control (information processing in distribution and management operations).

MACRO-ANALYSIS AND FORECASTING

The Technical Strategy for the Exploratory Development Program in Logistics required only minor changes in FY78. Efforts to adapt and exploit existing resource allocation R&D methodology to the needs of the Logistics Applied Research program continued. As part of this effort, an analysis of shore-based personnel resource allocations to logistics (including maintenance) by skill category was completed.

SEALIFT, BASING, AND UNDERWAY REPLENISHMENT

Navy Emergency Air Cargo Delivery System (NEACDS)

During FY78 the Navy Emergency Air Cargo Delivery System (NEACDS), an at-sea air drop system for emergency resupply of Naval Fleet units, was exercised by both the Atlantic and Pacific fleets. Using commonly available off-the-shelf materials, NEACDS provides an emergency delivery capability for resuppling priority cargo to ships at sea from fixed wing aircraft via airdrop without putting a man or boat in the water during retrieval under conditions through sea state 4. This emergency capability is an augmentation of normal naval resupply methods and can be used in remote geographic areas or under conditions which do not permit normal resupply.

CMLD has been involved in the development of this system since FY74. As a demonstration of the system, inert loads of sonobuoy torpedoes (see Figure 42) and STANDARD ARM and SHRIKE missiles, weighing from 5000 to 9000 pounds, were delivered to ships at sea by Air Force C-141 aircraft during several exercises. The latest participation was during Exercise TEAM SPIRIT in the Pacific. NEACDS is now an operational capability for which OPNAV Instruction 3980.2 was issued in February 1978. DTNSRDC has, as its final requirement, been tasked to write the chapter concerning emergency airdrop in the latest revision of the naval warfare publication (NWP) on Logistics.

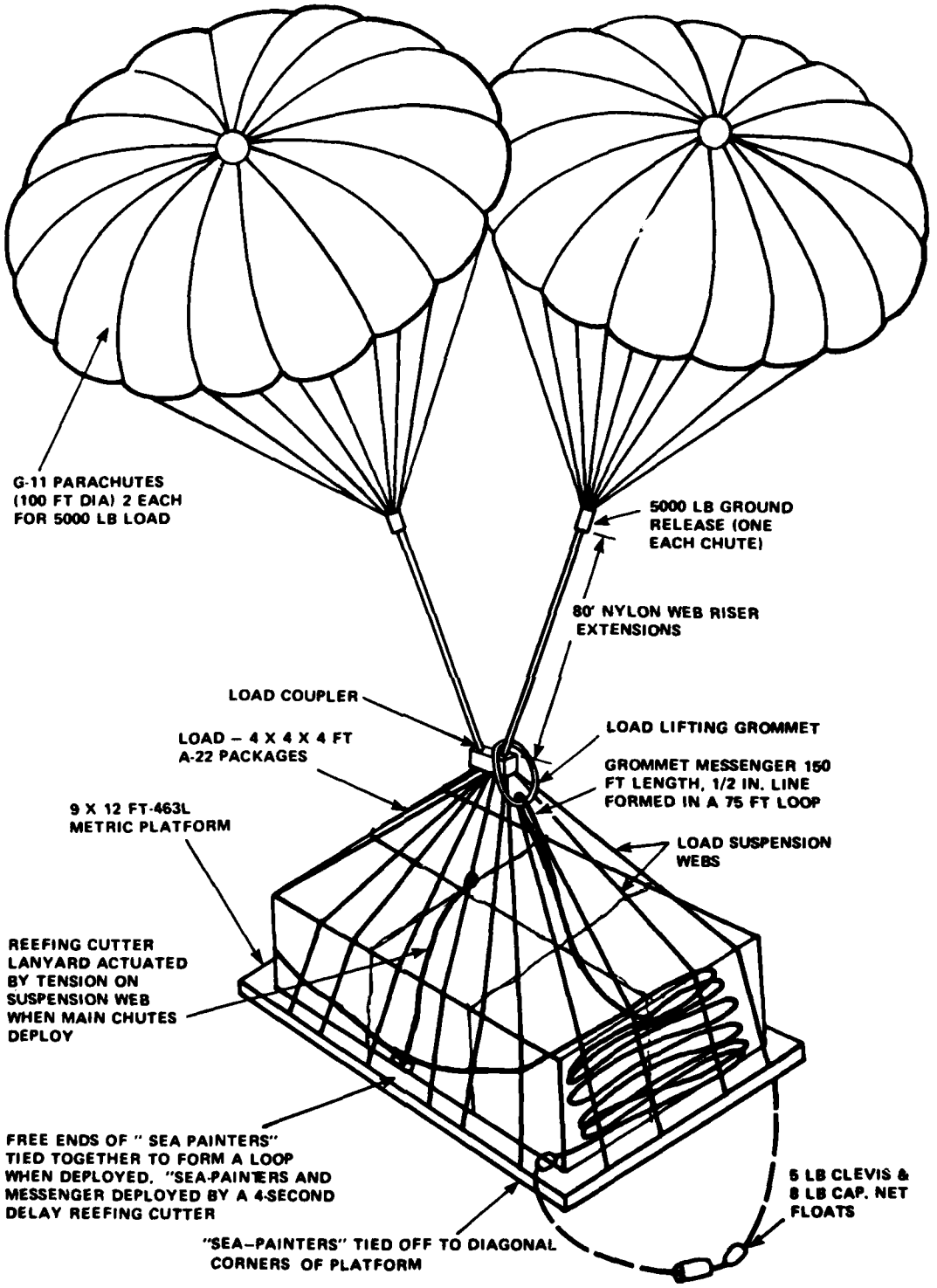


Figure 42 - Heavy Airdrop "Six-Pack" Load in Chute Deployed Descent Configuration

Amphibious Logistics Support Ashore (ALSA)

The complexity of USMC logistics has been increasing due to changing military environment, changing technology, reduction of resources, decreasing availability of amphibious ships, and increased reliance on merchant ships. Consequently, there is a need to examine logistics requirements ashore to evaluate and design efficient support procedures and equipment. The Amphibious Logistics Support Ashore (ALSA) project is developing analytical tools in the form of flow networks, measures of effectiveness, and computer simulations (1) to study and evaluate currently used procedures and equipment and (2) to establish a basis for evaluating advanced technology and guiding the Marine Corps research and development program. A computer simulation of the evolution of the amphibious area from an undeveloped littoral area to a fully organized beach and logistic support area was developed in FY78. Some pilot cases have been run and analyzed. These cases indicated that the model is a reasonably valid representation of the construction and cargo flow through the amphibious rear areas as they evolve. As a follow-on effort to this work, a separate subsystem model for petroleum, oil, lubricants, and ammunition is being developed.

LOGISTICS SUPPLY SYSTEMS

Transportation Operational Personal Property Standard System (TOPS)

The purpose of the Transportation Operational Personal Property Standard System (TOPS) is to provide a standard means of processing the information required in the operation, management, and movement of personal property for members of the armed services and their dependents. CMLD's effort involves identifying the changes in procedures needed to provide a standardized, simplified personal property movement and storage system and a cost-benefit analysis of methods for automating that system.

The concepts of TOPS, which began as a Navy-only research and development effort, were recognized by OASD in February 1977 when the military services were tasked to develop TOPS as a joint effort and the Navy was named as executive agent. Because of its capability in the analysis of

distribution networking and the potential applications of computer technology to the solution of Navy distribution problems, DTNSRDC has been assigned lead laboratory responsibility for coordinating development of the system. Representatives of the Air Force, Army, Marine Corps, and Military Traffic Management Command worked with the CMLD staff to eliminate discrepancies in the current manual system and to provide common development efforts for all the services. This team has completed a Functional Description which details the current procedures for moving personal property and describes the data and procedures of the proposed system. A prototype test system designed to evaluate the cost-benefits of TOPS (using networked minicomputers) is scheduled for pilot testing at the Charleston and Pensacola Personal Property Transportation Offices. In FY78 a macro-level study of major alternate TOPS configurations, involving basic recommendations for the field test configurations and major requirements documents, was completed and issued, and specifications for the Navy segment of the test system were developed and issued.

This project represents one of the first times DTNSRDC has been involved in the complete development of a DoD logistics operational system from the initial research and development concept to implementation of the automated system.

Container Oriented Network Distribution Analysis (CONDA)

The objective of the Container Oriented Network Distribution Analysis (CONDA) project is to determine the extent, types, and manner in which containers should be utilized in the Navy Supply System by providing NAVSUP with a management tool for analyzing and evaluating route patterns and rate structures for breakbulk and seavan cargo shipments. The approach used is to identify, describe, and simulate network flow in the supply system, using actual historical data. This approach requires the development of a large complex data base which, using the SHARP data base management system, will provide input to a computerized network simulation program.

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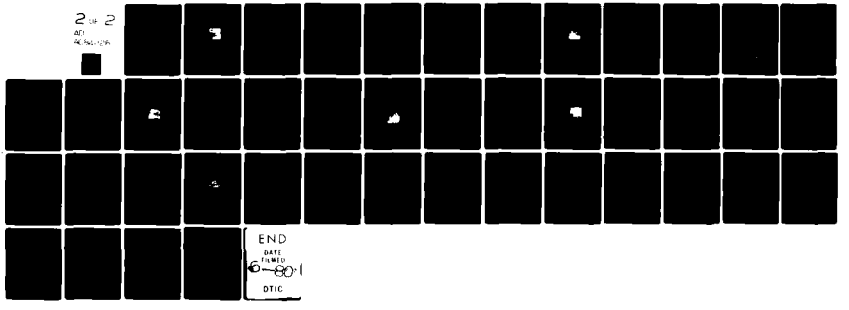

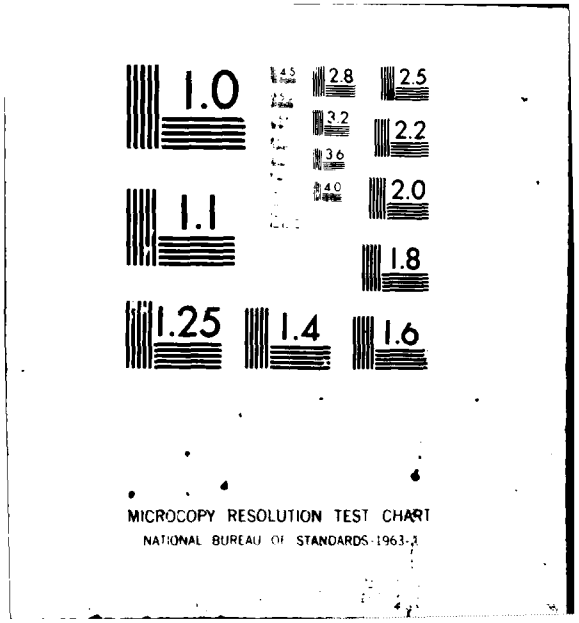
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The project effort during FY78 was devoted largely to continuing the collection of CONUS route pattern and cost data and to completing an application program for visual representation of port-to-port cargo route patterns. In addition, a transportation network computer model for the solution of large-scale minimum cost network transshipment and transportation problems was acquired and exercised in the development of the network flow process descriptions.

During FY78 these programs and data were used in the analysis of cargo movement and costs of seavan operations. The breakbulk data are also available for analysis as needed. When completed, CONDA will have the capabilities to evaluate trade-offs for contingency planning, determine future consolidation terminals within CONUS, and result in a significant savings in computer costs. NAVMTO has expressed interest in using CONDA as a management tool.

Warehouse Computer Simulation Model

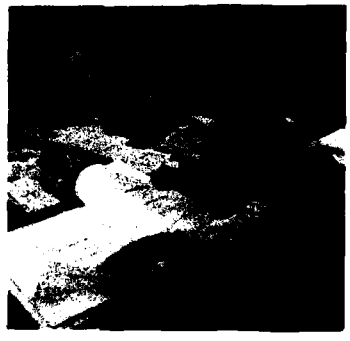
The Naval Supply Systems Command has recognized a need for a flexible technique for determining, testing, and evaluating facilities and equipment needed to modernize warehouses or to make present facilities more efficient. They therefore tasked DTNSRDC to develop a functional flow computer simulation program for use as a tool in evaluating warehouse modernization proposals, especially as they relate to warehouse equipment and system configurations.

The operations of the Charleston Naval Shipyard were used as the basis for the study. CMLD developed the simulation model and during FY78 used it to simulate movement within a warehouse under several conditions. A graphical technique provided a means for comparing modifications with the current utilization of personnel, materials handling equipment, and pallet traffic.

The Logistics Division had the responsibility for the development of a field manual for use by operational supply system personnel which will permit a rational quantitative assessment of warehousing requirements. This effort, in conjunction with a contractor and the NAVSUP sponsor, culminated in the publication of NAVSUP's "Warehousing Modernization and Layout Planning Guide".

Small Parcel Handling System (SPHS)

In FY78 the Small Parcel Handling System project was initiated to establish the feasibility of utilizing alternative methods to the current system of distributing material packaged in small parcels. The approach developed is to identify the Navy stock points from which small parcel shipments originate and the requisitioners; estimate the quantities; define a family of potential alternative modes of shipment; establish on a cost-benefit basis the service improvement potential, if any; compare the alternatives to the current system; and recommend the best course of action.



Depot Maintenance Project

CMLD has been tasked by the Naval Sea Systems Command (NAVSEA 070T) to develop a computerized means of forecasting depot-level repair and alterations work. Two systems have been developed under the Depot Maintenance Project over the past four years--the Depot Maintenance Planning and Programming System (DMPPS) and the Depot Maintenance Ship Work Breakdown Structure System (DMSS). The systems project expenditures (in terms of labor and materials) for overhauls of Naval vessels. The projections are by Ship Work Breakdown Structure (SWBS) and/or by shipyard production shop. The forecasts produced by the systems permit assessment of the impact on shipyards and ship systems of changes in depot-level maintenance/alterations policy, major changes in force levels or fleet composition, and fiscal constraints.

Both systems have been installed on the NAVSEA 070T computer terminal and have been operated successfully in full scale trial runs. Data used for these initial runs were obtained primarily through visits to the Naval shipyards, by manual extraction of required data from shipyard Departure Reports, and from computer data tapes on completed shipwork prepared quarterly by the Naval shipyards for the Depot Maintenance Project. However, few tapes were available at the time the initial data bases were compiled. Automated procedures are being developed for processing the shipyard tapes and integrating the data into the DMPPS data bases. This task was initiated in FY78 and will be completed during FY79. It includes analysis of the data to identify trends or patterns in the distribution of repair work or alteration work between overhauls of similar ships.

Initial Replacement Rates (INREP)

The objective of the Initial Replacement Rates (INREP) project is to investigate the feasibility of using engineering test data to improve the stocking, provisioning, and inventory of Navy repair parts by assignment of initial replacement rates. The approach used is to examine the current provisioning process and the kind of data used. Other data sources are then identified and their effect on the provisioning process is determined.

During FY78 the existing provisioning process was examined and current data were obtained. A detailed literature search of government, industry, and academic sources was conducted to identify sources of failure/replacement rate data. The Government-Industry Data Exchange Program (GIDEP) and the Reliability Analysis Center (RAC) were identified as possible sources of data.

The effort during FY79 will compare current Navy data with GIDEP/RAC information to determine the effect of engineering test data on the provisioning process. Commonly represented equipment components and assemblies will be selected for detailed analysis. The feasibility of using the GIDEP/RAC data as a supplement to the existing Navy data will be determined.

CONTROL AND INFORMATION PROCESSING

Afloat Information Material Movement Study (AIMMS)

NAVSUP has the responsibility to supply NAVSEC with supply support and maintenance space requirements as they pertain to new ship design. The Afloat Information Material Movement Study (AIMMS) was undertaken to provide NAVSUP with a software simulation and an analytical method for determining the relative locations aboard ship of supply support and related maintenance activities, the equipment and space for these activities, and their manning requirements. During the year project personnel collected relevant data at sea aboard USS RANGER (CVA-61). The information acquired will be used as reference material in the development of the simulation program logic flow for supply systems on typical aircraft carriers. The simulations will be the basic analysis vehicle for establishing better transfer of information and/or materials procedures and design among supply support and related maintenance activities, for improved repair (maintenance) turnaround time, and for more effective assignment of personnel. Since carriers represent the most complex ship systems, the methodology developed will have potential application, through modification of the simulations, to other new ship designs and construction and to ship refit/overhaul.

Proof of Shipment/Proof of Delivery

CMLD has been exploring the use of advanced data capture techniques in an effort to improve the documentation and control of local deliveries from supply centers without causing unacceptable delays in the flow of deliveries. Operations at the Naval Supply Center, Norfolk, continue to provide the basis for the study, but the anticipated benefits in improved delivery and greater control and accountability should be transferable to other supply centers.

During FY78 the flow of material and information within the Norfolk Naval Supply Center complex, particularly in local delivery operations, was studied and formal descriptions were prepared. Mark sensing technologies (e.g., CODAVAR, OCRA, UPC) for rapid data capture, of potential use in this application, were examined and their capabilities compared.

Charts and descriptions of flows were completed, and additional data capture technologies were studied. Recommendations resulting from this work will be made to NAVSUP and the recommended technology will be exercised experimentally.

Logistics Application of Automated Marking and Reading Symbologies (LOGMARS)

During FY78, CMLD was tasked to provide technical assistance for Navy participation in a joint service program addressing logistics applications of automated marking and reading symbologies. The purposes of this program are to develop DoD-wide standards for the marking of material with automatically-readable markings, to assess the impact of this technology on DoD and its suppliers, and to develop an implementation plan. Overall, the effort will include development of descriptions and analyses of the flow of material and information in the DoD logistic system, the development of concepts for application of this technology, the evaluation of available equipment, and the planning and execution of necessary tests. During FY78, CMLD participants made major contributions to the working documents and reports of two key DoD working groups in the areas of study methodology, descriptions of material flows in the Navy, concepts for application, and test methodology and objectives.

Automated Vehicle Scheduling (AVS)

Under NAVSUP sponsorship, the Logistics Division has developed a set of Automated Vehicle Scheduling (AVS) programs to facilitate scheduling of palletized cargo movements at the Navy Supply Center (NSC), Charleston (see Figure 43). In addition to the average daily workload at Charleston of 400-600 pallets to be moved among 72 locations, emergency orders must be serviced as quickly as possible. The AVS package consists of four separate programs, two for actual scheduling and two for data entry. The first two programs, one of which creates schedules from the list of regular orders and the other which fits emergencies into the existing schedules on a fast-as-possible basis, are nearly complete and contain many user options for controlling the schedule building procedures. These programs were given preliminary tests in FY78. The two data entry programs provide the capability for immediate data entry, data validity checking, automatic scheduling of the schedule-preparation programs, and rapid availability of

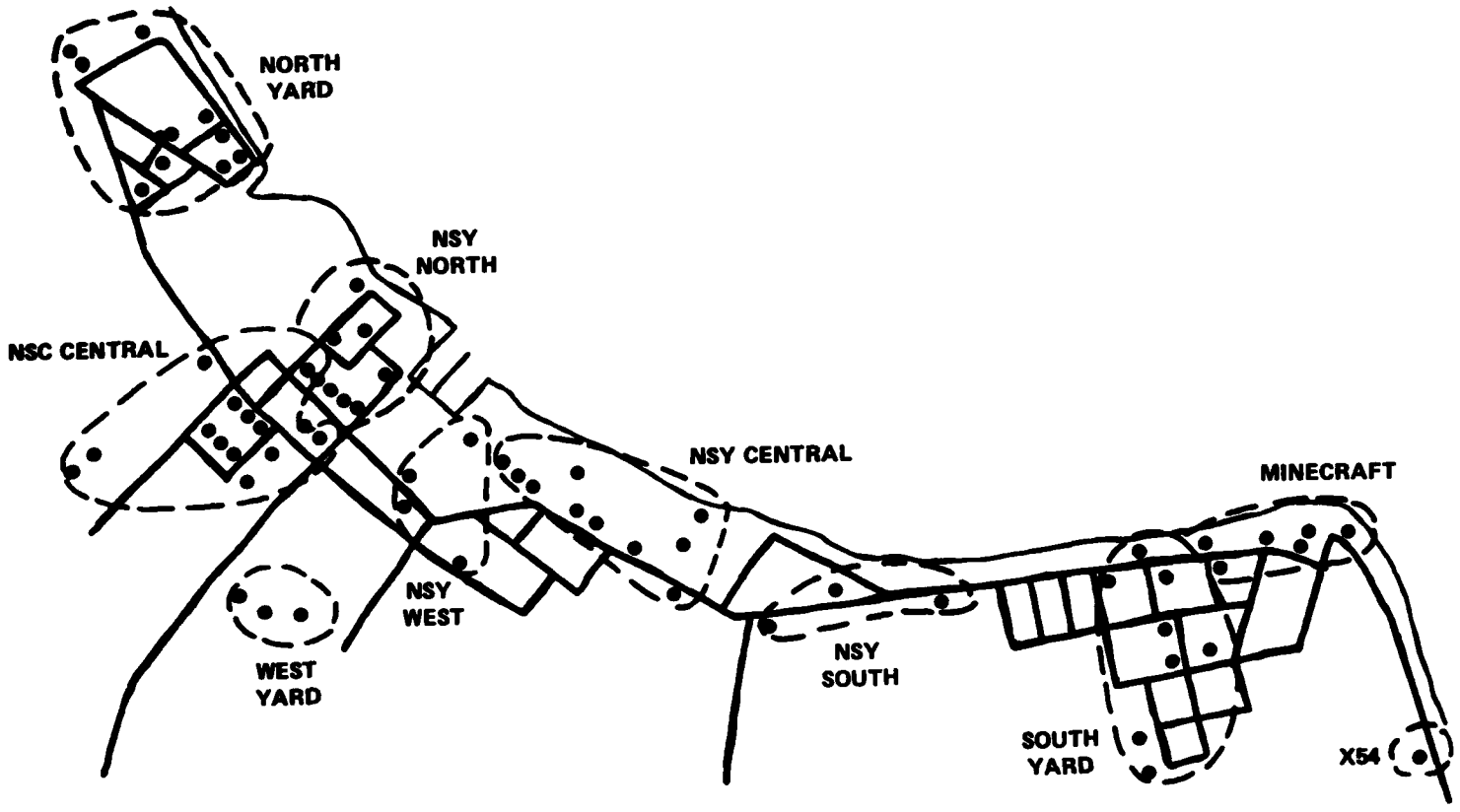


Figure 43 - Pick-Up/Delivery Sites (On Base)

hard copy schedules. Field testing arrangements have been completed at NSC Charleston. In addition, NSC Charleston has asked that some ancillary management reporting programs for performance monitoring and preventive maintenance purposes be written. This set of programs constitutes the primary candidate for adoption as Part V (local delivery) of the Navy Automated Transportation System (NAVADS).

MSC Sealift Support and Analysis (SEASAN)

CMLD was tasked by the Military Sealift Command (MSC) to explore the data generated by the MSC budgetary and financial management system and to develop techniques and measures of effectiveness for use in analyzing their transportation system in terms of operational performance, costs, and the interrelationships with MSC assets and shipping options. The primary purpose was to provide COMSC with a basis for internal review, decisions, and planning.

The initial (3-month) phase of SEASAN was, by direction, devoted to evaluating current MSC dry cargo operations, developing concepts of operational performance, evaluating controlled assets, and devising a system to present pertinent information derived from available data to the operations management in a manner commensurate with operational requirements. The resulting conceptual system was labeled the MSC Operations System (MOPS)

An MSC Navy Industrial Fund (NIF) Automated Data Processing (ADP) System is in operation at MSC. All MSC data acquisition and computer output is oriented to the requirements of this fiscal process and not to the management of MSC transportation operations, assets, and resources. The objective of the MOPS effort was to provide the MSC Operations Office (and perhaps the Area Commands) with historical and current data on assets, requirements, and operations status; to provide the tools necessary to project the MSC operation into the immediate (and to a lesser extent to the longer range) future; and to provide these data and projections in a manner compatible with the functions, operations, and reports of the operations staff.

The functional requirements of the Operations Staff and the MSC Area Commands were defined in terms of the data input and output from each office. The physical, computational, and communications requirements were delineated. The current operations of the pertinent offices were also analyzed in terms of the functions performed and the reports produced. This information was consolidated and reviewed by MSC personnel to assess its correctness and practicality.

A conceptual MOPS was then developed and a plan devised for its implementation. After further review by the potential user, the MSC Operations Office, the MOPS conceptual description and implementation plan were delivered to MSC as the final report on the project.

ADVANCED CONCEPTS FOR MAINTENANCE OF
TASK FORCE COMBAT READINESS

In FY78 CMLD was tasked by NAVAIR 03P3 to develop a proposal for "Advanced Concepts for Maintenance of Task Force Combat Readiness". Technological advances that may have potential for enhancing the ability of aviation and other Naval forces to maintain combat readiness, even at long distances from support bases and for extended periods of time, will be highlighted for further study. The first phase of the work will establish base line data from studies, current operations, and technological advances; define the capabilities of operating procedures of current forces; establish a notional task force; and establish a scenario for task force operations. The second phase will utilize these data to determine shortfalls in postulated future operations. Emerging technological advances, such as the work with heavy lift helicopters, will be analyzed for

application to the shortfall. Feasibility demonstrations or tests will be proposed during the course of the work.

NAVY TECHNICAL INFORMATION PRESENTATION PROGRAM (NTIPP)

During FY78, the Department made significant progress in the development of the Navy Technical Information Presentation System (NTIPS). A preliminary NTIPS concept generated in FY77 was further developed; modifications and supplemental research to the concept recommended by the SYSCOM's and Training Community were carried out; specific tasks were established to improve the concept; and a complete system logic was established. In addition, certain short-term developments and tests were conducted to provide known Techical Information (TI) improvements to the SYSCOM's and Training Community.

The interface between the Integrated Logistic Support (ILS) process and NTIPS was defined. The ILS and Logistic Support Analysis (LSA) procedures as currently defined were determined adequate to provide the data required by NTIPS. Specifically, the Logistic Support Analysis Record (LSAR) was identified as a major source of the required data. The problem is that the Navy does not generally follow the prescribed procedures. It was concluded that NTIPS must assist in the enforcement of the ILS procedures and also provide the capability to develop its own requirements information in specific cases where ILS/LSA is not carried out.

Another important NTIPS interface is with the Training Community. Currently the Training Community has no consistent position in providing input to the definition of the TI training requirements. The trend in the Navy since 1973 has been toward increasing use of Technical Manuals in training, but these manuals are often unsuitable. The key source of training requirements information is also the Logistic Support Analysis Record.

In the area of graphics comprehensibility, improved formats for presentation of TI to enlisted technicians were tested at various Navy training activities. The following ratings were included in the test: boiler technicians, machinist's mates, fire control technicians, gunner's mates, aviation electrician's mates, construction mechanics, sonar technicians, electronic technicians, aviation structural mechanics, and aviation

machinist's mates. To determine whether TI comprehensibility varies with the technician's skill level, pay grades E3, E4, E5, and E6 were tested. The data from the sample of 640 personnel are currently being analyzed.

A readability workshop was sponsored. Experts from the Navy, Army, Air Force, and industry participated. It was concluded by the NTIPP Office that (a) readability as a concept is of low utility in improving TI; (b) comprehensibility of graphics is seriously neglected; (c) training in technical areas must be tied to the TI actually used in the Fleet; and (d) maintenance simulators may possibly be used in developing methods for improving the usability of TI.

The current status of relevant TI production and delivery technologies was reviewed. All technology required for full NTIPS automation is considered feasible. Prototypes for all the functions can be built. The big payoff areas are in improved TI update capability and configuration management. These areas have not been incorporated in existing automated single-function systems, but they could be. Variable-medium output is not now common, but equipment could be configured to handle it. The problem areas requiring additional research in order to automate NTIPS are automatic page formatting for variable media, mass storage, and wide band communications. Figure 44 depicts some of the relevant TI production and delivery technologies.

The implications to the Navy of an all-digital NTIP System were identified. The all-digital system offers the following benefits:

matching the TI to varying experience levels
compatibility with on-the-job-training
easy TI update and configuration management
compact data storage
extendable by communications links
amenable to proceduralized job aids
capable of covert data collection

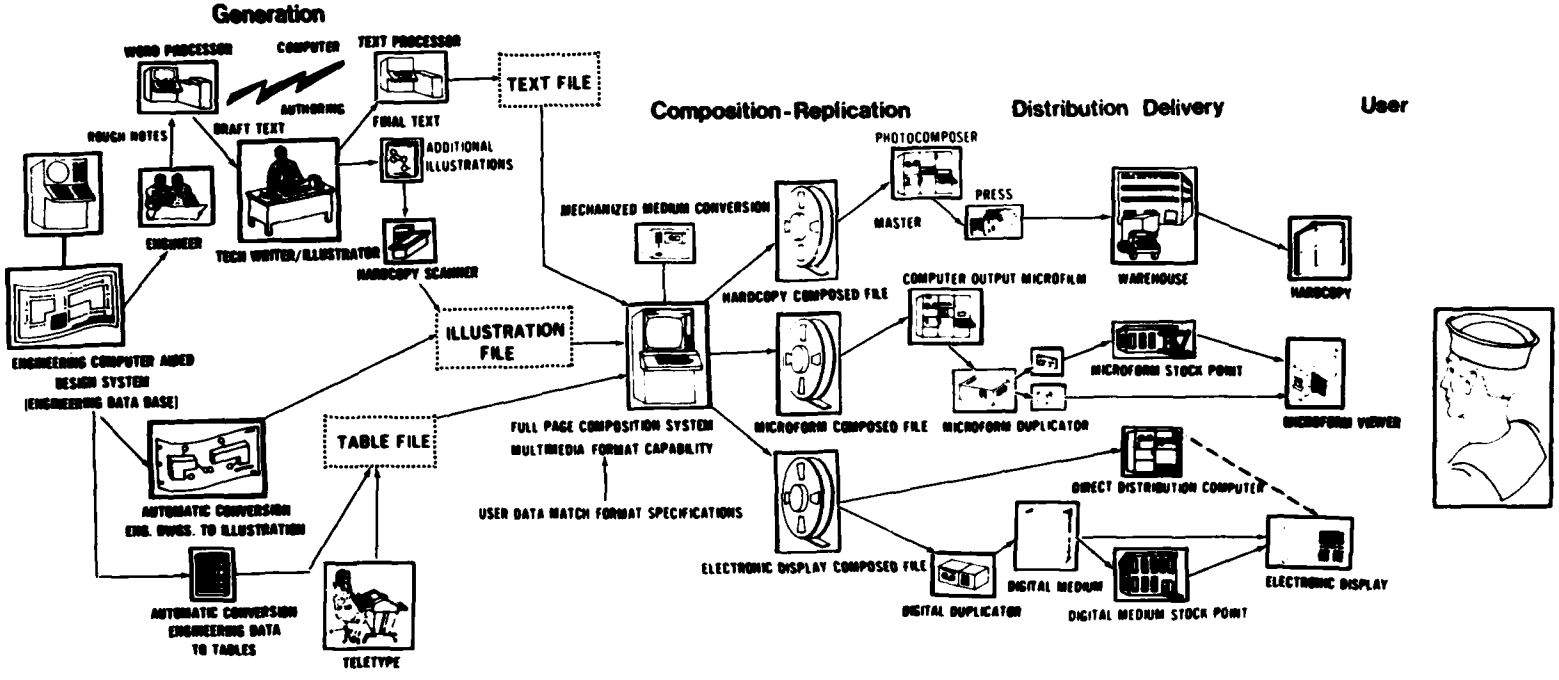


Figure 44 - Some TI Production and Delivery Technologies Relevant to NTIPS

In order to realize the full potentiality of such a system, however, development is needed in the following areas: (a) intelligent laser scanners for graphics input; (b) data compression, management, and retrieval; and (c) optimal interactive software. Figure 45 illustrates a possible all-digital configuration.

The format for presenting ejection procedures for the T-2 aircraft was revised in order to test improved comprehension and recall methods at Pensacola and Meridian. An increase in the comprehension and recall of safe ejection procedures of as much as 47% was obtained. An instruction will be developed for use by NAVAIR in rewriting other aircraft manuals.

The concept of modular specifications was developed. In this concept a computer selects and compiles individualized requirements statements (specifications) for each kind of TI required from precomposed modules related to a variety of factors such as user characteristics, job tasks, and job environments. The required information is determined by using logistics support analysis (LSA) information as input and the user-data match approach developed by NTIPP. A unique modular specification is thus provided for each TI item. NAVSEA is currently preparing to implement this concept.

An improved TI quality assurance (QA) approach was developed. QA is required early in the TI generation process, before resources are expended. The requirement for monitoring the TI procedures was established. The key evaluation points and criteria were identified and integrated into the NTIPS concept. A QA specification is being developed for NAVAIR use.

The concept of computer authoring was further developed. In this concept, the computer is preprogrammed to write course material. Selected programs have been completed, a user's guide has been prepared, and a program listing has been published. This technique is applicable in NTIPS for preparation of all contract documents required to define the TI.

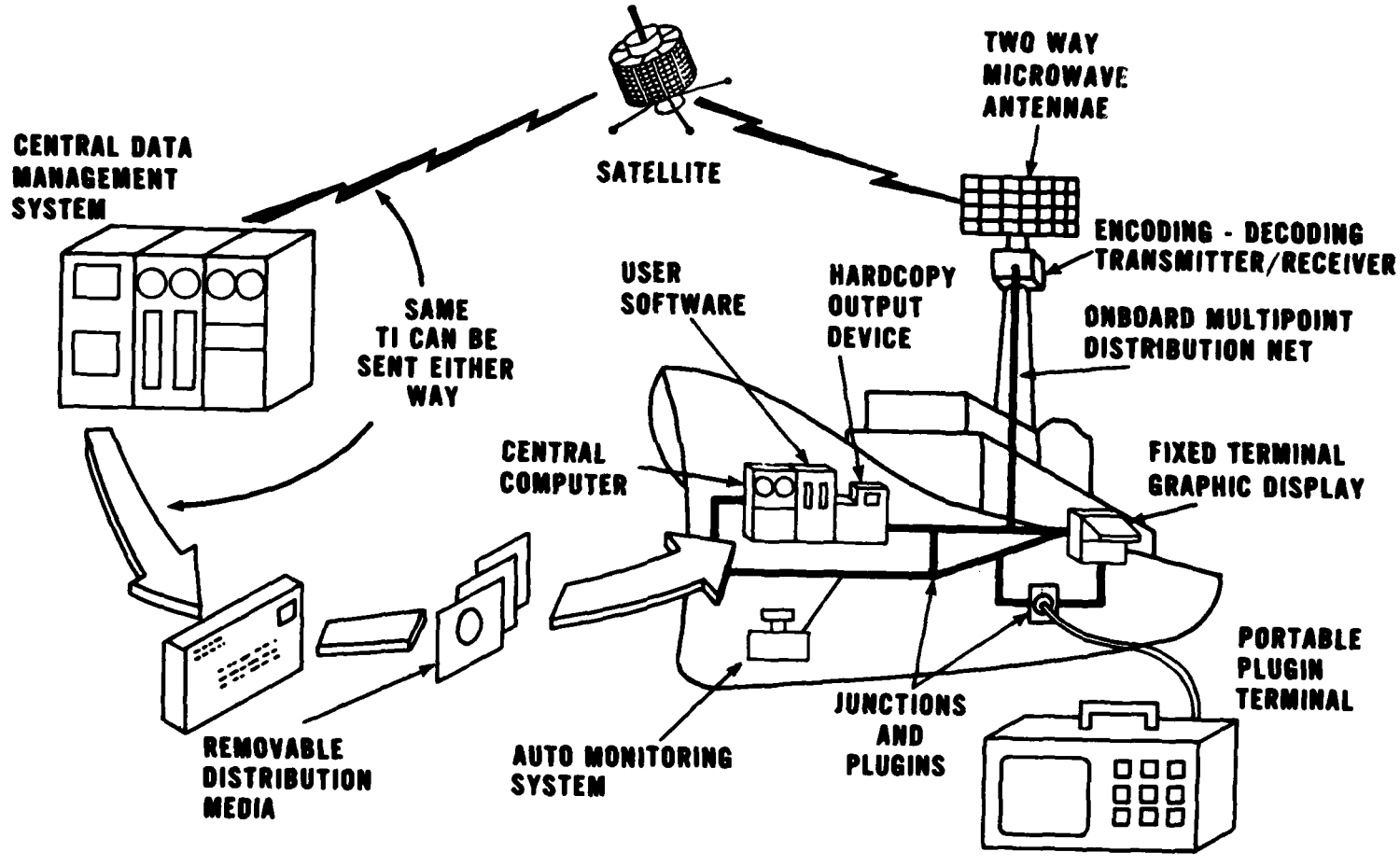


Figure 45 - A Possible All-Digital Configuration for TI Distribution and Delivery

The research findings discussed above have been incorporated into the preliminary NTIPS concept, and a complete system logic has been established. The concept is now adequate for initiating in FY79 the critical element design and testing and the detailed system design. Completion of the system design is scheduled for the end of FY81. Prototype tests will be conducted in FY82 and FY83 and implementation recommendations will be provided to NAVMAT.

MILITARY EFFECTIVENESS

The Military Effectiveness Office was established to conduct studies and analyses in support of DTNSRDC and Navy sponsored RDT&E programs. The main analytical thrust during the past year was in Design Performance Evaluations (DPE) and effectiveness studies to support the SSN 688-Class Improvement and Advanced Attack Submarine programs at NAVSEA; analytical support to the Ship Survivability Office at NAVSEC; Technology Planning and Appraisal Division of NAVSEA; Modeling support to CNA for DDX ASW studies; interfacing with the Advanced Naval Vehicles Study Group; participating as DTNSRDC representative on the Anti-Ship Torpedo Defense (ASTD) Program Evaluation Panel and the Naval Warfare Advisory Group (NWAG); and supporting some small special studies for other departments at the Center.

SYSTEM STUDIES

A number of analytical investigations and assessments were conducted for various sponsors. Some examples of accomplishments during the period include:

- An assessment of the relative effectiveness of current and proposed submarine acoustic warfare systems in enhancing submarine survivability to determine the potential payoffs that might be derived from equipping future SSN's with various acoustic warfare suites.

- A review and evaluation of five Navy-developed submarine warfare ASW engagement models to identify the most suitable model for simulating the functional and sequential operating features of key subsystems of the SSN Combat System.
- The development of a systematic procedure to ensure that subsystem models proposed for use in simulating the SSN's Combat System incorporate the necessary subsystem parameters and operational use of the subsystem. The generalized procedure makes use of a tabular format for rating/evaluating the applicability of a particular subsystem model used in the simulation effectiveness analyses of candidate SSN designs.
- An evaluation of the operational significance of acoustic transients in the detectability of U.S. attack submarines. The detectability of the steady-state signature was determined and compared to the combined steady-state/transient signatures.
- An end-to-end analytical methodology for assessing the impact of antiship threats on combat survivability of candidate ship designs and a procedure for systematically evaluating the effectiveness of a ship's total defense suite, including all factors such as signatures/reflectivities, active defense systems, countermeasures, and passive (mechanical) protection features which impact on overall ship vulnerability/survivability.
- Modeling and analysis support to CNA in installing and exercising the Navy's APSURF simulation model on the CNA computer for effectiveness analyses in specified mission roles of the candidate sonar and weapon suite under consideration for the DDX.
- An analysis of the operational payoffs of reducing submarine target strength by structural design modifications. Alternate SSN designs were evaluated against a postulated threat active sonar. (This study was undertaken in conjunction with ongoing technology developments in the Structures Department.)

- An analysis of CGN 42 acoustic detection and detectability vis-a-vis a postulated threat SSN. Various schemes for quieting CGN 42 self- and radiated-noise were evaluated. (This study was undertaken in conjunction with ongoing technology developments in the Ship Acoustics Department.)

SHIP COMBAT SURVIVABILITY STUDIES

During the past year, work continued on the NAVSEA/NAVSEC Design and Threat Unification Method (DATUM) project for surface ship combat survivability, although efforts were on a reduced level due to funding cuts. The analytical efforts concentrated primarily on the development and documentation of an end-to-end methodology for incorporating ship signatures and resulting aim point/hit point distributions for RF- and IR-homing antiship missiles, active defense systems (both hard-kill and soft-kill), and passive mechanical protection. Development of the Combined Active/Passive Defense Analysis (CAPDAN) model continued; this model is used in conjunction with the Ship Vulnerability Model (SVM) to evaluate the expected impairment and protection tradeoffs as a function of the number of threat weapons which hit the ship, whereas CAPDAN does it as a function of the number of threat weapons which penetrate the area (outer zone) defenses but must still cope with the ship's active point (inner zone) defenses.

SPECIAL SUPPORT

At the request of the Structures Department, a senior member of the Military Effectiveness Office was made available to serve as the DTNSRDC technical representative on the Navy's Proposal Evaluation Panel (PEP) for the Anti-Ship Torpedo Defense (ASTD) development program. The PEP is a working group responsible for providing technical support to the ASTD project as follows:

- Assist during the pre-bid conference
- Evaluate Competitive Concept Formulation (CCF) proposals
- Make recommendations for contract award to the Contract Award Review Panel (CARP)/Source Selection Authority (SSA)
- Assist in contract monitoring and review
- Support GFI data requirements
- Assist in developing CCF evaluation criteria
- Assist in evaluating CCF results
- Conduct special investigations as requested

The Center's expertise in ship vulnerability (to underwater weapons) was solicited to provide technical support needed to effectively prosecute the ASTD project.

A senior member of the Military Effectiveness Office served as one of the Center's principal members (the other being the Assistant Technical Director for Special Programs) on the Naval Warfare Advisory Group (NWAG) reporting directly to the Director of Navy Laboratories (DNL). The NWAG, comprised of senior analysts from the Navy Laboratories and APL/JHU, was established by the DNL to foster a coordinated effort among the Navy Laboratories/Centers in studies/analyses/operations research and in analysis of Fleet exercises.

Several analysts from the Military Effectiveness Office participated in the analysis for the RIMPAC 78 exercise.

STATISTICAL CONSULTATION

During FY78 the Statistical Consulting Staff supported a number of scientific, engineering, and management projects both at DTNSRDC and at other Navy activities. Short term consultation services and indepth project participation covered Reliability/Maintainability/Availability (RMA) Analysis of Ship Systems, Strength of Materials Evaluation, Shipboard Pollution Abatement, Management Program Evaluation, Facilities Workload Analysis, and Ship Performance. Aspects of statistical and probability theory recommended or applied to various projects ranged from the design of data collection experiments to methods for the drawing of inferences and conclusions from experimental results. In addition, the staff arranged for two colloquia, one on old but little used methods for the evaluation of repairable systems failure rate data, and the other on some new analysis techniques for level crossing problems in random time series.

FY78 work included the following highlights:

RMA ANALYSIS

The Staff provided technical review support on the reliability/maintainability demonstration procedures contained in the Technical Evaluation Master Plans (TEMPs) of the recently developed oil free air compressor system and on shipboard oil/water separators. Reliability/maintainability data analysis support was also provided during the TECHEVAL of the air compressor, results of which were included in the request for an OPEVAL demonstration.

Work on providing statistical services to the Reliability Engineering Section of the NAVSEC Ship Design Division, initiated late in FY77, continued. MTBF and MTTR values of so-called "bad actors" (shipboard subsystems identified as contributing significantly to mission unreliability from simulation studies) were compared among several new ship designs. Updated MTBF/MTTR values on selected equipment were forwarded to be included in subsequent simulation studies. Recommendations were also made to attach optimization software to the TIGER simulation program currently used by NAVSEC for RMA design studies. The optimizer would predict minimum MTBF/MTTR values on bad actors to meet mission RMA requirements.

SHIPBOARD POLLUTION ABATEMENT

From data collected during previous shipboard surveys under the Navy Environmental Protection Support Service (NEPSS) Program, Autoregressive Integrated Moving Average (ARIMA) models were developed to describe the random time fluctuations of the waste flow. Subsequently, these models were applied in the classical Stochastic Storage Equation to model and predict the content of various types of holding tanks for waste retention and to recommend design capacities.

SPECTROMETRIC OIL ANALYSIS

Investigations were conducted for NAVSEC on the applicability of sample spectrometric oil data collected under operational conditions in predicting oil wetted parts failure and extending overhaul cycles. Recommendations were made to add certain measurable variables to data collection procedures and to conduct special experimental efforts in order to improve the detectability of unusual sample values.

FACILITIES WORKLOAD EVALUATION

A special study was conducted for the Industrial and Facilities Directorate to evaluate historical data on workload and assess work backload problems. Recommendations for improving scheduling procedures and data base management were made.

EXPENDABLE BATHYTHERMOGRAPHS (XBTs)

Data from at-sea tests of a random sampling of Navy stock and new expendable bathythermographs were analyzed to determine the source of high failure rates occurring during tactical usage. High failure rate sequences were related to shipping quarter and manufacturer's serial number, with high failure rate XBT batches clustered in relation to storage location.

SSBN MATERIAL CONDITION ASSESSMENT

CMLD has continued to provide statistical support to the SSBN Ship-system Maintenance Monitoring and Support Office of NAVSEC in monitoring major SSBN subsystems so that, through improved preventive maintenance practices, the overhaul and repair cycle of the ships may be extended. Statistical techniques of distribution theory and quality assurance have been applied to data collected for three SSBN classes. Probability bounds for various types of measurements were used to ensure the quality and integrity of data received by engineers who recommend and schedule preventive and overhaul maintenance activities. In addition, modification of a main propulsion system analysis model was begun.

COMPUTER FACILITIES

At DTNSRDC, computers and computer technology are an integral part of the Research and Development process. The computer facilities of the Computation, Mathematics and Logistics Department constitute a major Navy computer center serving the scientific and management information processing needs of DTNSRDC and other Navy and government agencies. The Computer Center provides around-the-clock computer processing to more than 1500 registered users located in 12 states. The facility operates on a fully reimbursable basis in which the total cost for operating the Center (e.g., equipment, salaries, supplies, etc.) is reflected in the cost that the user pays for computational services.

HARDWARE AND SOFTWARE FACILITIES

The computational services offered by the Computer Center include local and remote batch processing, interactive processing, and interactive graphics processing. These basic computational services are supported by off-line plotting, printing, microfilm, and microfiche processing.

During FY78 the major general purpose computing facilities at the Center were the CDC 6700/6600 shared system and the CDC 6400. Major hardware/software components of these systems are summarized as follows:

6700/6600 Shared System

6700 Processor (6600 and 6400 CPU's)

6600 Processor

131,072 60-bit words of central memory (each)

20 peripheral processor units (each)

4 printers (shared)

6 7-track tape drives (shared)

2 9-track tape drives (6700)

28 844 disk drives (shared)

4 844 double density disk drives (shared)

2 card readers (shared)

2 card punches (shared)

high, medium, and low speed communications ports (shared)

CDC 6400 System

6400 Processor

131,072 60-bit words of central memory

10 peripheral processor units

3 printers

8 7-track tape drives

1 card reader

1 card punch

high, medium, and low speed communications ports

Related Equipment

The following equipments are off-line to the CDC 6000's:

CALCOMP Plotters (Models 936, 763, 170)

Datagraphix Computer Output Microfilm (Model 4060)

Datagraphix Computer Output Microfiche (mini autocom)

Graphics Data Reduction and Design Station (PDP-11/40 & Altek Digitizer)

Xerox 1200 Printing System

A wide variety of computer software is available for use with the CDC 6000 computers and the related peripheral equipment. Software has been obtained from Control Data Corporation (CDC), the user community, software vendors, cooperating user groups, and the Computer Center Staff. In varying degrees, each of these sources has provided software in the following general categories:

Operating System Software (NOS/BE, INTERCOM, etc)
General Compilers (FORTRAN, COBOL, etc.)
Utility Routines (File copies, etc.)
Library Subroutines (Mathematical functions, etc.)
Special Compilers/Languages (MIMIC, APT, SPSS, etc.)
Systems Level Application Software (NASTRAN, etc.)
Data Base Management Systems (SHARP, Systems 2000, etc.)
Graphics Software (IGS, DISSPLA, Plot subroutines, etc.)

Combinations of this software and users' programs can be processed concurrently as local and remote batch, conversational, and active graphics jobs under the operating system NOS/BE (Network Operating System/Batch Environment).

OPERATIONS AND WORKLOAD

Each system was operated for three shifts daily with considerable weekend processing. In addition, the Computer Center staff was responsible for operation and maintenance of several support systems such as the Datagraphix mini autocom, Microfiche unit, the CalComp plotter, and several remote batch terminals. To augment the limited resources of the operations staff, contractor services were required on several shifts.

The overall Computer Center workload increased significantly in FY78. Number of jobs processed daily and number of files maintained on-line daily are listed in Table 1. Although the Computer Center user community extends beyond DTNSRDC, most of the workload processed by the Center in FY78 was in support of Navy related scientific and engineering (R&D) projects. Table 2 gives workload percentages by organization. Table 3 summarizes income by ADP resource.

TABLE 1 - WORKLOAD DATA FY78

MONTH	AVERAGE DAILY NUMBER OF JOBS CDC 6000's	AVERAGE NO. OF FILES ON-LINE DAILY	PERCENT AVAILABILITY OF (CPU, PPU, ETC.) 6700	6600	6400
Oct	2259	12046	99.6	98.4	99.8
Nov	2288	12328	99.6	99.9	98.9
Dec	2141	12798	99.8	99.2	94.3
Jan	2257	12672	98.1	98.1	99.6
Feb	2373	13261	96.1	98.1	99.6
Mar	2509	13941	99.2	98.8	99.6
Apr	2456	14103	95.9	99.3	99.8
May	2622	14073	95.8	98.7	97.1
Jun	2498	14140	97.9	99.1	96.9
Jul	2496	13935	98.9	98.7	98.9
Aug	2649	14914	98.3	99.3	99.6
Sep	2760	14457	98.5	98.1	99.2
Averages	2442	13556	98.1	98.8	98.6

TABLE 2 - COMPUTER UTILIZATION BY USER ORGANIZATION--FY78

USER	PERCENT
System Development	3.11
Ship Performance	5.45
Aviation and Surface Effects	2.74
Structures	12.70
Computation, Mathematics and Logistics	8.31
Ship Acoustics	1.62
Propulsion & Auxiliary Systems	2.69
Ship Materials Engineering	.90
Central Instrumentation	.12
Financial Management	13.69
Civilian Personnel	2.99
Other DTNSRDC	1.25
Naval Air Systems Command	5.15
Naval Sea Systems Command/Naval Ship Engineering Center	17.61
Other Navy	8.00
Office of Naval Research/Naval Research Laboratory	.60
Other Department of Defense	3.01
Other Government	9.76
Private Contractors	.30
TOTAL	100.00

TABLE 3 - INCOME BY ADP RESOURCES--FY78

FACILITY	PERCENT OF INCOME
CDC-6000's	81.6
Other Government	.6
EAM	.6
Equipment	7.6
Miscellaneous	9.8
TOTAL	100.00

ADP SERVICES

While availability of computational processing time is the prime service offered by the Computer Center, other services for the computer user are also provided. Classes directed toward assisting users in more efficient use of computer facilities were offered to 155 users. Consultation on the use of the operating systems and of all the compilers and special software packages was available from 7 AM to 6 PM daily. Documentation on current use of the CDC 6000 was made available to users through two revisions to the Computer Center Reference Manual. Users were kept informed of changes to the system hardware and software through Computer Center Notes which are mailed to all registered users and through SYSBULL which is printed at beginning of each computer job.

Computer Center personnel are responsible for supporting the DTNSRDC ADP Policy Official in processing requests for automatic data processing equipment and services. During FY78, 118 ADP approval requests were processed.

FY78 MILESTONES

To provide broader and more comprehensive computer capabilities for the many users of the computer center, several hardware acquisitions were made:

- An additional CDC 2550 communications system was added with additional telephone lines to handle medium speed remote batch and low speed interactive terminals.
- Four double density disk drives were added, increasing disk storage capacity by 860 million characters.
- Magnetic tape capability was augmented by adding the ability to read and write at 1600 bits per inch.
- The microfiche capability was enhanced by upgrading to a Datagraphix COM unit with its own mini computer, giving capability to process tapes from most vendors' hardware.
- The Center's printer capability was broadened by installing a Xerox 1200 printer which allows formatted computer reports to be printed at reduced size on $8\frac{1}{2}$ x 11 paper ready for binding.

- To further serve the user, approximately 40 terminals, including remote batch, conversational, and graphics, were acquired.

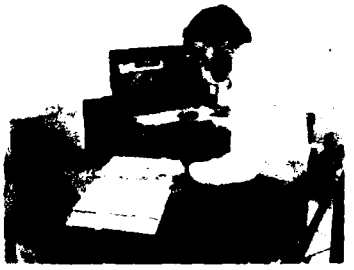
In addition to hardware acquisitions many enhancements were made to the 6000 software.

- The NOS/BE operating system was upgraded to a higher level with minimal impact on the user.
- Vendor supplied user audit was replaced by a locally written faster implementation.
- Access numbers replacing job order numbers were installed to further protect the user.
- An automatic logout after 15 minutes of inactivity was implemented, allowing broader sharing of heavily used telephone lines.
- A user initiated on-line ADP accounting program was made available so that account managers may quickly check accumulated expenditures.

ADVANCED SYSTEM DEVELOPMENT PLANS FOR FY79

The requirement for a conversational processor to provide improved interactive services was approved and a contract signed with Burroughs Corporation for a new computer system, the B7700, to be installed in early FY79. Building 193, adding 8000 square feet of space for new equipment, will house the B7700. Initially the B7700 will be installed as a stand-alone system with interactive processing as its prime shift workload and batch processing after 6 PM. The current plan is to network the three CDC systems (currently in operation), the B7700 conversational processor (partially installed), and a trillion-bit Mass Storage System (MSS) (in procurement). The Advanced Systems Development Group, formerly the Advanced Computer Facility, is planning and directing the overall implementation of this network.

The three CDC systems and the MSS will be networked using CDC long line adaptors currently under development. The steady increase in work processed by the Computer Center has almost saturated the CDC 6000 system and as a result work has begun on specifications for a Batch/Interactive system or systems to replace the CDC 6000 systems. The estimated delivery date for the replacement system(s) is mid 1982. At least two years of operation of the network will permit the development of the necessary interfaces to the replacement system. The MSS, using the long line adaptors, is compatible with most major vendors.



The Communications Processor task has been deferred because the Burroughs B7700 Conversational Processor will be installed with a Front End/Data Communications Processor with the required capability.

DTNSRDC NALCON

The Navy Laboratory Computer Network (NALCON) has as its goal the sharing of computer resources among a number of Navy Laboratories. The approach has been to link the laboratories' computers via the ARPANET. At DTNSRDC the NALCON configuration consists of a PDP-11/40 "front-ending" our CDC 6400. Users at DTNSRDC may access other computers on the ARPANET for interactive purposes by dialing the PDP machine and requesting connection to the desired host. Six teletype ports at 300 bits per second and two ports at 1200 bits per second are available for this purpose.

Interactive access to our CDC 6400 computer by external users of the ARPANET is similarly available. Four teletype lines at 300 baud connecting the PDP-11 to the CDC 6400 are used to implement this capability.

Future plans call for enhancement and expansion of current NALCON facilities. A channel interface between the PDP-11 and the CDC 6400 has been ordered and can be expected to provide faster interactive access to the CDC machine for ARPANET users. It will also allow File Transfer and RJE capabilities to be developed. Facilities allowing the transfer of text data files on the CDC 6400 to or from cooperating ARPANET hosts should be a reality within a year.

The Navy Laboratory Computer Committee (NLCC) is responsible for developing quality of service standards for computer support of scientific and engineering personnel of the Naval laboratories in the areas of computer availability, batch turnaround time, interactive response time, and related services. These standards must be validated, and means of monitoring them must be established. During this year, DTNSRDC evaluated the proposed batch quality of service standard for its validity. A base figure was calculated for comparing job sizes on the different computer systems, and a synthetic (FORTRAN) benchmark job was run a number of times. A scenario for interactive studies was agreed upon and tested. A test run of batch turnaround data was made and plans were set up for collecting additional batch turnaround data during FY79, based on accounting files. Specifications were developed for a hardware monitor for interactive response time studies.

APPENDIX A
REPORTS PUBLISHED IN FY78

NUMBER	DATE	TITLE	AUTHOR
GENERAL			
77-0106	Oct 77	Computation and Mathematics Department Report for Fiscal Years 1976 and 7T	------
NUMERICAL ANALYSIS			
78-033	Mar 78	An Investigation of Three Computer Programs for the Solution of AX = B where A is Symmetric and Sparse	D.A. Gignac
78-060	Aug 78	Multiple Linear Regression	G.R. Humfeld
78-075	Aug 78	A Comparison of Three Computer Programs for the Solution of AX = B where A is Symmetric and Sparse	D.A. Gignac
CMLD-78-13	Sep 78	Stepwise Multiple Linear Regression Routine Batter and IMSL Routines RLSTEP, RLFORC, RLSUBM and MDFD	G.R. Humfeld
NUMERICAL FLUID DYNAMICS			
77-0118	Nov 77	The Texas Instruments Advanced Scientific Computer and Its Application to Numerical Fluid Dynamics Problems	P.E. Morawski
78-050	Jun 78	A Discrete Vortex Simulation of a Two-Dimensional Shear Layer with Prediction of the Hydrodynamic Noise (Supersedes CMLD-77-26 Dec 77)	W.G. Grabowski J.G. Telste
78-058	Aug 78	Autorotation of Plates	H.J. Lugt
78-065	Aug 78	NASTRAN Implementation for Free Surface Flow Problems	P.R. Zarda M.S. Marcus

NUMBER	DATE	TITLE	AUTHOR
78-085	Sep 78	Boundary-Fitted Coordinate Systems for Three-Dimensional Regions Containing Ship-Like Bodies	R.M. Coleman
CMLD-77-26	Dec 77	A Discrete Vortex Simulation of a Two-Dimensional Shear Layer with Prediction of the Hydrodynamic Noise	W.G. Grabowski J.G. Telste
NUMERICAL STRUCTURAL ANALYSIS			
78-019	Feb 78	A Guide to Use of the XWAVE Program: Part II - Scattering of Sound Waves from Rigid Structural Surfaces	F.M. Henderson
78-057	Jun 78	The Response of a Submerged Stiffened Cylindrical Hull to an Oblique Shock Wave (U) CONFIDENTIAL	G.C. Everstine Y. Wang (PSAD)
CMLD-78-04	Mar 78	Specifications for a Solid Finite Element Data Generator	R.J. Kazden
DATA STRUCTURES AND MANAGEMENT			
78-045	May 78	Feasibility Study for Incorporating a Data Structure Definition and Manipulation Facility within the Comrade Data Management System	I.S. Zaritsky
COMPUTER GRAPHICS			
CMLD-78-07	Jul 78	The Interactive Image Display System	M. Haas M.B. Marquardt
MACROANALYSIS AND FORECASTING			
78-021	Feb 78	Depot Maintenance Planning and Programming System (DMPPS): Volume 2 - Preprocessor Subsystem	L.L. Lamatrice J.K. St. Laurent
78-022	Jul 78	Depot Maintenance Planning and Programming System (DMPPS): Volume 3 - Alterations Subsystem	L.L. Lamatrice J.K. St. Laurent

NUMBER	DATE	TITLE	AUTHOR
78-023	Jun 78	Depot Maintenance Planning and Programming System (DMPPS): Volume 4 - Repair Subsystem	L.L. Lamatrice
78-024	Feb 78	Depot Maintenance Planning and Programming System (DMPPS): Volume 5 - Synthesizer Subsystem	J.K. St. Laurent
78-025	Aug 78	Depot Maintenance Planning and Programming System (DMPPS): Volume 6 - Report Generator Subsystem	J.K. St. Laurent L.L. Lamatrice
78-026	Jun 78	Depot Maintenance Planning and Programming System (DMPPS): Volume 7 - Feedback Subsystem	M.J. Lamatrice
CMLD-78-08	Aug 78	Long Range Planning System/Workload Graph Interface Programs	L.L. Lamatrice
SEALIFT/BASING/UNREP			
77-0117	Dec 77	Naval Emergency Air Cargo Delivery System (NEACDS) Feasibility Tests and Evaluation	R.H. Putnam M.J. Zubkoff et. al.
78-017	Sep 78	DEAS Information Network Study Phase 2 - Comparison and Compatibility Analysis	B. Siegel C. Ash
78-020	Jan 78	Depot Maintenance Planning and Programming System (DMPPS): Volume 1 - Executive Summary	L.L. Lamatrice
MAINTENANCE AND REPAIR			
78-070	Aug 78	A Comparison of Analytic and Simulation Reliability and Maintainability (R/M) Prediction Methods	M. Gray
MILITARY EFFECTIVENESS			
CMLD-78-06	Mar 78	Review/Evaluations of Submarine Warfare and ASW Engagement Models for Application to SSN Combat System Effectiveness Assessments	S. Goldstein R. Shaffer

NUMBER	DATE	TITLE	AUTHOR
ENGINEERING ANALYSIS AND APPLICATIONS			
78-069	Aug 78	Theoretical Analysis of Swing-Pad Bearings with Small Imperfections	C.W. Dawson P. Morawski

APPENDIX B

TECHNICAL PUBLICATIONS/PRESENTATIONS FY78

Eddy, R.P., "Extrapolating to the Limit of a Vector Sequence," Proc. Workshop on the Linkages between Applied Mathematics and Industry, Naval Postgraduate School Monterey Ca., 23-25 February 1978. Edited by P.C.C. Wong, Academic Press.

Everstine, G.C., H. Huang (NRL), and Y.F. Wang, "Retarded Potential Techniques for the Analysis of Submerged Structures Impinged by Weak Shock Waves," Computational Methods for Fluid-Structure Interaction Problems, edited by T. Belytschko and T. Geers, AMD-Vol. 26, ASME, New York, November 1977, pp. 83-93.

Feingold, H. (DTNSRDC) and H. Asher (NRL), "Is There Repair After Failure?", presented at the Reliability and Maintainability Symposium, Los Angeles, Ca., January 1978.

Feingold, H. (DTNSRDC) and H. Asher (NRL), "Application of Laplace's Test to Repairable System Reliability," presented at the Conference on Reliability and Maintainability, Paris, France, June 1978.

Frenkiel, F.N. and P.S. Klebanoff, "Further Measurements of the Small-Scale Turbulence Structure," presented at Second Seminar on MHD-Flows and Turbulence held at Ben-Gurion University of the Negev, Beer-Sheva, Israel, 28-31 March 1978.

Frenkiel, F.N., "On Advances in the Study of Turbulence during the Past Thirty Years," presented at 30th Annual Meeting of the Division of Fluid Dynamics, American Physical Society, Bethlehem, Pa., 21-23 November 1977.

Frenkiel, F.N., "Recent Directions in Turbulence Studies," presented at Second Seminar on MHD-Flows and Turbulence held at Ben-Gurion University of the Negev, Beer-Sheva, Israel, 28-31 March 1978.

Frenkiel, F.N., "Small Scale Structure of Turbulence," lecture given at a seminar sponsored jointly by University of Houston and Rice University, Houston, Texas, March 1978.

Frenkiel, F.N., M.T. Landahl, and J.L. Lumley (editors), "Structure of Turbulence and Drag Reduction," published as Part II of the October 1977 issue of The Physics of Fluids as well as a separate bound volume.

Frenkiel, F.N. and D.W. Goodall (of Australia) (editors), "Simulation Modelling of Environmental Problems," published by John Wiley & Sons on behalf of the Scientific Committee on Problems of the Environment (of the International Council of Scientific Unions) as SCOPE Report 9, 1978.

Frenkiel, F.N., R.J. Emrich, J.R. Dorfman, W.C. Griffith and G. Veronis, "Thirty Years of Fluid Dynamics," Physics Today, Vol. 31, September 1978, p. 38.

Haussling, H.J. and R.J. VanEseltine, "Waves and Wave Resistance for Air-Cushion Vehicles with Time-Dependent Cushion Pressures," J. Ship Research, Vol. 22, September 1978.

Jefferson, D., "DTNSRDC Support of Research in Very Large Data Base Systems," Third International Conference on Very Large Data Bases, Tokyo, Japan, October 6-8, 1977.

Jefferson, D., "Computer-Aided Documentation and Analysis of Requirements," Data Comm 78 Conference, Washington, D.C., February 21-23, 1978. Also served as session chairman.

Jefferson, D., "Engineering Data Management: Experience and Projections," Conference on Engineering and Scientific Data Management, NASA Langley Research Center, May 18-19, 1978.

Lugt, H.J. and H.J. Haussling, "The Acceleration of Thin Cylindrical Bodies in a Viscous Fluid," J. of Applied Mechanics, Vol. 45, p. 1, March 1978.

Marcus, M.S., "A Finite-Element Method Applied to the Vibration of Submergence Plates," J. Ship Research, Vol. 22, No. 2, June 1978, pp. 94-99.

Schot, J.W., "Further Advances in Numerical Fluid Dynamics at DTNSRDC," Annual DEA Meeting on Viscous and Interacting Flow Field Effects, Monterey, California, April 1978 (Published in Boundary Layer Effects--Proceedings of the 7th U.S. Air Force/Federal Republic of Germany DEA Meeting, Air Force Flight Dynamics Laboratory Technical Report 78-111, Wright-Patterson Air Force Base, Ohio, September 1978).

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Zarda, P.R. and M.S. Marcus, "Finite Element Solutions of Free Surface Flows," Sixth NASTRAN Users' Colloquium, NASA CP-2018, October 1977, pp. 27-52.

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